RANCHO LA BREA

A Record of Pleistocene Life in California

by

CHESTER STOCK

LOS ANGELES COUNTY MUSEUM June 1, 1949

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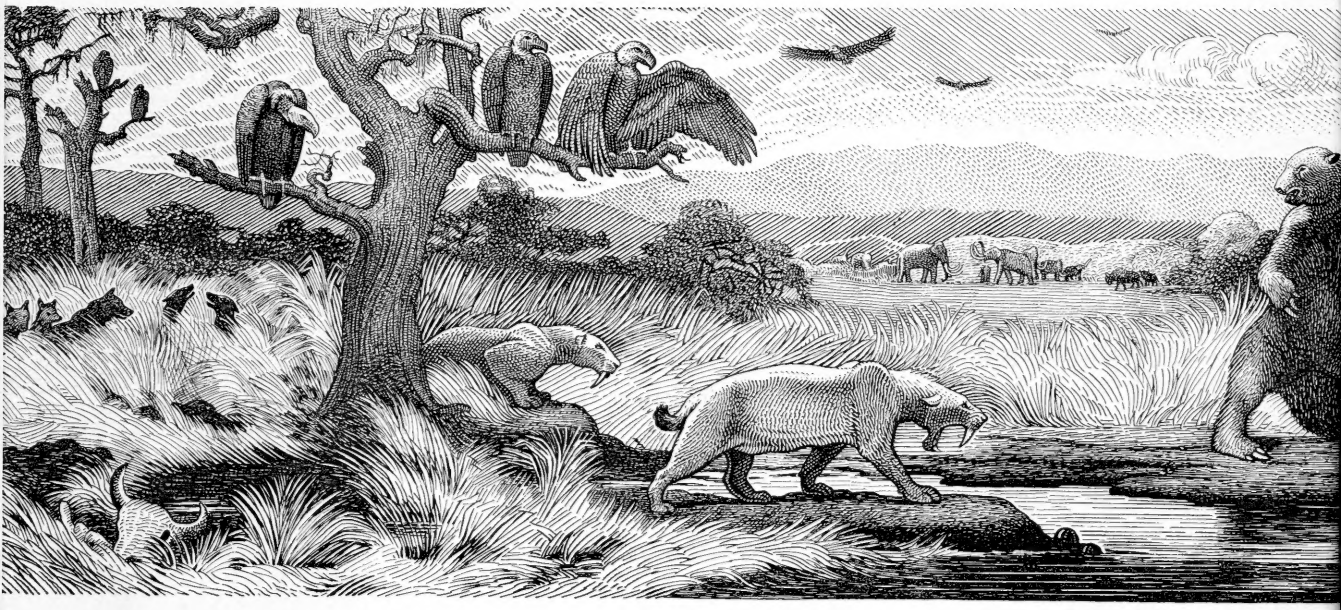

From a Drawing by WILLOUGHBY after a Mural by KNIGHT in the Los Angeles County Museum

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FOURTH EDITION

LOS ANGELES COUNTY MUSEUM

Science Series, No. 13 Paleontology, No. 8

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INTRODUCTION

THE UNIQUE COLLECTION of fossils obtained from the asphalt deposits of Rancho La Brea has no parallel among the numerous records of the past life of the earth brought to light by the paleontologist and geologist. Closest approach in age, nature of preservation, and in kinds of materials preserved is made by two additional brea occurrences in California; one located at Carpinteria, Santa Barbara County, the other at McKittrick, in Kern County. Dating from a period not very remote in earth history, yet possessing presumably considerable antiquity as measured in terms of years, the collection from Rancho La Brea furnishes a basis for reconstruction of a remarkably clear picture of life as it existed in the Los Angeles region of Southern California in late geologic time.

Among the outstanding features of the Rancho La Brea collection are the great wealth of material, the unusual variety of the species, and the fine state of preservation of the remains. The abundance of well-preserved skulls and skeletal elements makes it possible to prepare mounted skeletons of many of the characteristic mammals and birds. The specimens displayed in Hancock Hall of the Los Angeles County Museum are but a part of the collection obtained from the asphalt. In not a few types, individual skulls and parts of skeletons are duplicated many times by specimens not on exhibition. More than 200 different kinds of animals and plants are now known from Rancho La Brea. To this list probably other forms will be added as the study of the entire assemblage progresses.

It is not surprising, therefore, that the occurrence and collection have aroused considerable interest on the part of the scientific specialist and of the layman. Much intensive research during the past forty years or more has resulted in the accumulation of a fund of information relating to these deposits and their exhumed organic remains. This knowledge has been shared with the intelligent observer to whom fossils no longer make an appeal merely as objects of curiosity or as "Medals of Creation." The present review of our knowledge of these deposits and of their record of life is intended to further this interest and to serve the needs of the daily visitor to the exhibit hall of the Los Angeles County Museum and the site of Rancho La Brea.

ACKNOWLEDGMENTS

The writer has drawn freely on the results obtained by a large group of students who have concerned themselves with Rancho La Brea and its fauna and flora. The appended bibliography citing many papers relating specifically to Rancho La Brea furnishes at a glance the long list of contributors to this field of investigation. To Dr. John C. Merriam we are indebted particularly for valuable contributions to the many aspects of the Rancho La Brea occurrence and for his special studies of the Pleistocene mammals. The studies of Loye Miller have established likewise a very substantial body of facts concerning the birds

of the asphalt. Miss Ida DeMay collaborated with the author in the preparation of the second edition of the booklet published in 1942. Since then further revisions were made. In the third edition, and now in the fourth, the subject matter has received a substantial increase in new material. Likewise, the illustrations have been improved. It is a pleasure to acknowledge particularly the work of Eugene J. Fischer, veteran preparator on the technical staff, who is responsible for the construction of practically all the mounted skeletons of extinct animals from the asphalt now on display at the Museum.

HISTORY OF DISCOVERY AND DEVELOPMENT

Tar seeps or "springs of pitch" in the Los Angeles region were apparently first recorded by Gaspar de Portola in his diary of the Portola California Expedition of 1769-1770. An entry reads as follows: "The 3rd (August 3, 1769), we proceeded for three hours on a good road; to the right of it were extensive swamps of bitumen which is called *chapapote.*

FIG. 1. View looking northwest showing portions of Rancho La Brea and the Salt Lake Oil Field with Santa Monica Mountains in background. Exploratory excavations for fossils shown with pit 4, flooded, in middle foreground. Photograph taken February, 1914.

We debated whether this substance, which flows melted from underneath the earth, could occasion so many earthquakes." A second early report of the occurrence was made by Jose Longinos Martinez in the journal of his expedition to California in 1792 (see Simpson, 1938). He states that: "Near the Pueblo de Los Angeles there are more than twenty springs of liquid petroleum, pitch, etc. Further to the west of the said town, in the middle of a great plain of more than fifteen leagues in circumference, there is a great lake of pitch, with many pools in which bubbles or blisters are continually forming and exploding

... In hot weather animals have been seen to sink in it and when they tried to escape they were unable to do so, because their feet were stuck, and the lake swallowed them. After many years their bones have come up through the holes, as if petrified. I have brought away several specimens.

"For a great distance round about these volcanoes there is no water and, when the heat of the sun forces birds to seek water, they fall into the lake, which seems to them to be water. All the birds that come thus are caught by the feet and wings until they die of hunger and thirst. The same disillusionment overtakes rabbits, squirrels, and other animals. For this reason the gentiles are very careful to explore these places in order to hunt without work. Near San Buenaventura beside the highway, there are several other springs of bituminous petroleum, and at their side some others of the same pitch hardened."

The French explorer Duflot De Mofras makes the following statement in the account (1844) of his explorations in Oregon and California: "Two leagues to the southeast of Los Angeles there are four great sources of asphaltum, situated on a level with the earth in a vast prairie. These springs open in the middle of little pools of cold water, while the bitumen possesses a higher temperature. This water has a mineral taste, which, however, does not prevent animals from drinking it. At sunrise the orifices of these springs are covered by enormous bubbles of asphaltum, often being more than a yard high, and looking like soap bubbles." On the map accompanying this report De Mofras indicates the source of the bitumen in the plains west of Los Angeles.

Apparently the first cartographic record of the position of bituminous springs, which may be identified with those of Rancho La Brea, is that made by E. O. C. Ord in 1849. On a topographic sketch map of the Los Angeles plains and vicinity, issued with Lieutenant Ord's report, the location of pitch springs is shown at a point several miles west of Los Angeles and south of the gap in the mountains now known as Cahuenga Pass. The name Rancho La Brea referred originally to an old Mexican land grant in that area, but as now generally understood, the name applies more specifically to the plot of ground on which the fossil-bearing asphalt beds are located.

In 1853 the Los Angeles region was again examined as a part of the program of exploration for a railroad route from the Mississippi Valley to the Pacific Coast. In the report of this expedition the geologist William P. Blake describes (1856) the occurrence of bituminous deposits, possibly those of Rancho La Brea. Not until 1875, however, was a published statement made of the occurrence of skeletal remains of extinct animals in the asphalt deposits of Rancho La Brea. In that year William Denton gave an account of his visit to the brea ranch of Major Henry Hancock, and described the asphalt accumulations which were then being excavated for their tar content. He stated furthermore that Major Hancock presented him with a tooth which was later determined to be a canine tooth of a sabre-tooth cat. Denton at the time of his visit also secured bones and teeth of a fossil horse as well as other mammalian and bird remains.

The account given by Denton appears to have escaped further notice and apparently no interest in the occurrence of fossil materials at this locality was manifested by scientists until 1905. The importance of the fossil bones and teeth in the deposits was first recognized by W. W. Orcutt of Los Angeles. Late in 1905 the locality was visited by Frank M. Anderson and Mr. Orcutt, and a number of fragmentary specimens were collected including a portion of a sabre-tooth skull, jaws of a large wolf, and several dermal bones of a large ground sloth. The material was placed at the disposal of Dr. John C. Merriam of the

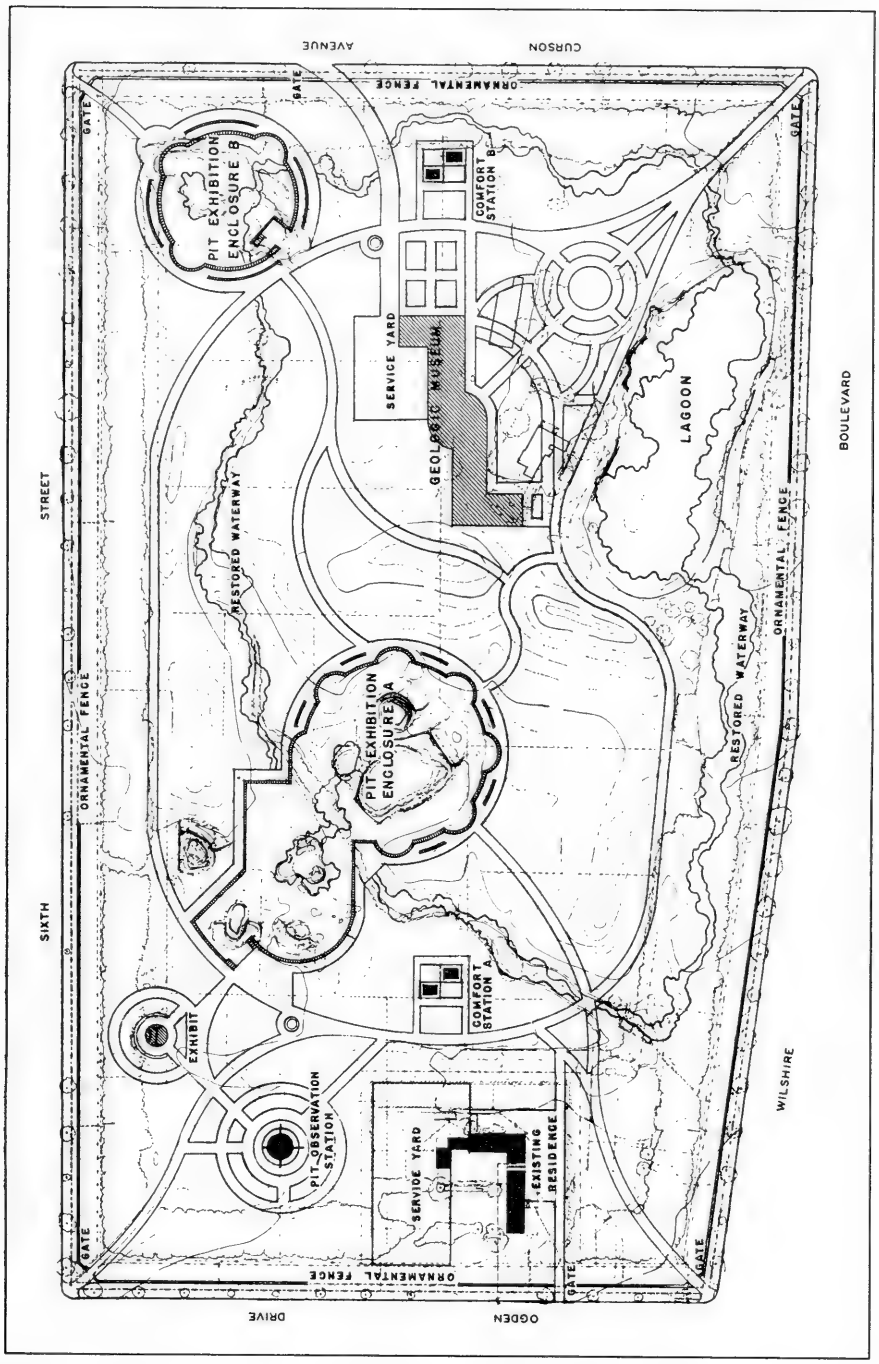

FIG. 2. Plan for development of Hancock Park on Wilshire Boulevard, Los Angeles, California, by Harry Sims Bent, Architect.

University of California. Dr. Merriam appreciated the significance of this discovery and on a visit to the locality was convinced that further excavating would yield larger collections.

Permission to excavate was kindly granted the University of California by Madame Hancock Ross and the subsequent explorations were carried on at intervals from 1906 to 1913. The Southern California Academy of Sciences, Occidental College, and the Los Angeles High School also obtained collections during that period.

In 1913 Mr. G. Allan Hancock granted Los Angeles County the exclusive privilege to excavate at Rancho La Brea for a period of two years. The excavations were conducted by the Los Angeles County Museum and the materials that were obtained are now preserved in this institution as the Hancock collection, a memorial to Major Henry Hancock and Madame Ida Hancock Ross. Although hundreds of thousands of bones were recovered from the asphalt, it is believed that many more still remain in the deposits.

In May 1915, Mr. Hancock generously gave the tract of land on which the famous fossil beds occur, approximately 23 acres, to Los Angeles County with a request that the scientific features of the site be adequately exhibited and preserved. A public park of unique character and exceptional interest, known as Hancock Park, has been established. The park faces Wilshire Boulevard on the south and is bordered on the west by Ogden Drive, on the north by Sixth Street, and on the east by Curson Avenue. A number of the original excavations made in search for fossil remains can still be seen. Plans prepared by the architect, Harry Sims Bent, call for new construction, and some of this has now been completed. Among the improvements is a building erected over a fossil occurrence in the western part of the park. This observation station or pit museum is so constructed as to permit the visitor to descend by a circular staircase to a promenade from which can be seen the bones and skulls of the ancient animals that were trapped and entombed during Pleistocene time, and subsequently brought to view again by the paleontologist. Within the park will be re-established as a living flora the trees, shrubs, and plants that grew in the region during the time of the Ice Age. There will likewise be shown in life size restorations a number of the characteristic animals described from the Rancho La Brea deposits.

Exudation of the tar and occasional entrapment of small animals can be seen in progress at the present time (figure 3). While the activity which has brought about the surface outpours has diminished considerably since the period of formation of the large asphalt deposits, the accumulations forming today give an impressive demonstration of the conditions and processes that prevailed during an earlier time. Within the corporate limits of metropolitan Los Angeles there still remains at Rancho La Brea an indubitable link with the reality of the geologic past.

POSITION IN GEOLOGIC TIME

Any attempt to reach a satisfactory understanding of the position of Rancho La Brea and its record of life in the geologic past must of necessity take into account the stratigraphic relationships of the deposits containing the fossil remains. The asphalt beds are essentially part of a sedimentary series consisting of sands, clays, gravel, and angular rubble whose present thickness is recorded to be from 40 to 190 feet as determined in the area of the old Salt Lake oil field, lying immediately to the north of the fossil beds (see page 19). Beneath these sedimentary deposits are older formations of marine shales and sand-

stones with interbedded oil sands from which the petroleum has come. The attitude and relationships of these older beds clearly indicate that they were folded and to some extent eroded prior to the accumulation of the more or less flat lying deposits containing the Rancho La Brea asphalt.

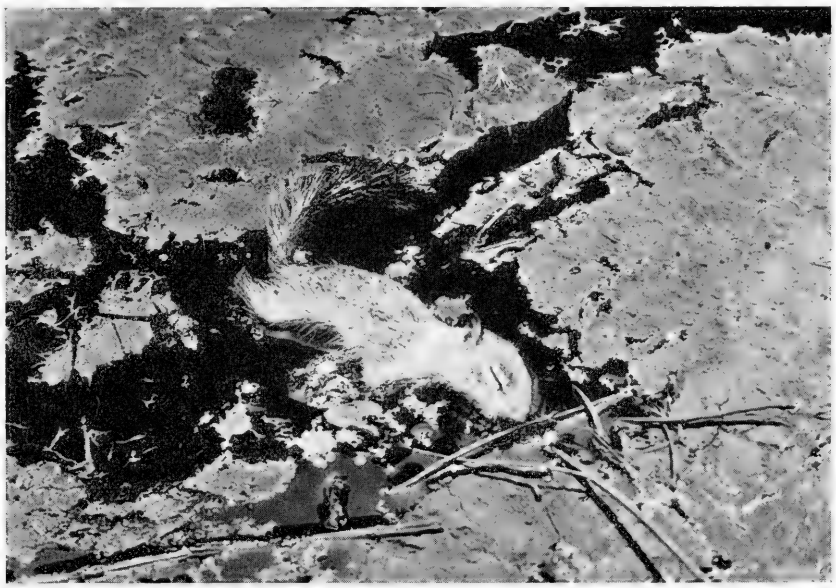

FIG. 3. Ground squirrel *(Citellus)* mired in Recent tar seep at Rancho La Brea.

Obviously, the earliest age which may be assigned to the latter strata is determined by the age of the latest beds affected by the folding and of the period of deformation and subsequent erosion. In the present instance no attempt is made to establish the length of time involved in these various events in terms of years, for an evaluation of this kind would yield at best but crude approximations in our present state of knowledge. The sequence and relative position of the events in the geologic time scale can, however, be determined with a considerable degree of accuracy.

Geological and paleontological investigations have now demonstrated that not only are later Tertiary marine strata folded in the Los Angeles basin area, but early Pleistocene deposits are likewise deformed (figure 4). In other words, the earth movements which brought about the folding of the older strata and the extensive erosion which followed this episode occurred within Pleistocene time, and mark an important break between the strata that accumulated before and after these events. The former beds, as Eaton points out (Eaton, 1928, p. 134) are everywhere deeply eroded and seldom show a gently sloping or horizontal attitude. The latter deposits with the asphalt lenses at Rancho La Brea retain their essential horizontal position of accumulation. If the time of these earth movements and erosion is middle Pleistocene, a view generally held by geologists, the Rancho La Brea occurrence can not be older than late middle Pleistocene.

Grant and Sheppard (1939, p. 308) suggest that the older alluvium containing the tar beds represents marginal deposits of the Hollywood alluvial fan. This fan is one of a number of similar fans forming the piedmont slope along the southern border of the

Santa Monica Mountains. In the western part of this region these fans are now being dissected by streams, a feature of the present cycle of erosion. The absence of any considerable thickness of sediments in the vicinity of Rancho La Brea, overlying the horizon of the asphalt beds, would appear to indicate that the conditions of accumulation have remained about as we find them today at this locality. In their geological studies of the Palos Verdes Hills, San Pedro, located 20 miles south of Rancho La Brea, Woodring, Bramlette and Kew (1946) point out that the alluvium in which the fossiliferous brea accumulations occur is probably of essentially the same age as the older alluvium which is now arched over the Dominguez Hills some 12 miles to the south. This older alluvium is regarded by them as essentially the equivalent of the non-marine cover of the lowest marine terrace on the face of the Palos Verdes Hills. Considerations of this kind lead inevitably to the view that the fossiliferous asphalt was laid down in later Pleistocene time.

Viewing the problem of age in the light of the paleontological facts, there can be no question that the deposits and the entombed record of life are not older than the latest geological epoch ante-dating the Recent, namely the Pleistocene. Many of the characteristic animals found at Rancho La Brea are similar to or identical with types described elsewhere from Pleistocene horizons. The position of Rancho La Brea in the geological time scale removes the element of surprise which may be manifested in the presence of a number of fossil animals and plants belonging to species that are still living. However, such changes as have occurred in the geographic distribution of many of these forms since the time of their entombment in the asphalt are, in themselves, an indication of the relative antiquity of the assemblage. Presence of many extinct animals brings to one the significant realization that wide-spread extinction occurred in the animal world of the Pleistocene since the time of entombment at Rancho La Brea. If this occurred in the later Pleistocene, the episode of extinction may be regarded as of relatively short duration.

All students of the fossil evidence are now convinced that the age of the Rancho La Brea assemblage is late in Pleistocene time. Just how late, however, is a matter of more than academic interest, and requires further investigation. Those species of animals found fossil in the asphalt, and which heretofore have been regarded as similar to existing types but are now considered as specifically different and ancestral to the living forms (see pages 33 and 58), tend to widen the gap between the fossil and living assemblages. In other words, a longer interval may have elapsed between past and present during which other faunal changes occurred in the region. Bearing on the problem of relative age is the relationship of the fauna of Rancho La Brea to fossil assemblages found elsewhere in southern California. Especially important are those related faunas that occur in Pleistocene terrace formations whose geological position in the Pleistocene sequence can be more clearly established than that of the Rancho La Brea deposits. Whether, for example, the Pleistocene assemblages from the brea beds and from the Palos Verdes formation are identical, is uncertain. Vertebrate fossils recently collected in the Palos Verdes appear to emphasize a difference from those found at Rancho La Brea, and while this difference may be slight, it suggests at least that the brea specimens are older.

While the accumulation of the fossiliferous asphalt and the entrapment of organic forms doubtless represent a long period of time as measured in terms of years, these events are assumed to furnish a cross-section of Pleistocene life for a relatively restricted time interval within this epoch. Nor has it been demonstrated that in the deposits, as they are known to us, there is evidence of continuous entombment extending into Recent time from a stage somewhere within the Pleistocene. The fauna obtained from the several

large pits excavated by the Los Angeles County Museum appears to be essentially a homogeneous one. To be sure, certain kinds of mammals as well as other forms are better represented in some pits than in others, but the possibility of a catastrophe overtaking an entire troop of elephants or a family of ground sloths in one pool can not be wholly disregarded. There are, however, elements in the entire Pleistocene fauna which suggest different ecological or environmental facies, perhaps due to differences in time. Thus, the mastodon, the ground sloth *Megalonyx,* peccaries, deer and timber wolves seem to indicate forest conditions and thus reflect an environment different from that normally occupied by the ground sloth *Paramylodon,* camel, bison, horses and many other mammals. Since the latter animals are also in the majority, is it possible that the accumulation of materials at Rancho La Brea continued during a time of changing climatic conditions such as might be expressed in the progress of events from the last glacial to the post-glacial stage? At any rate, the consensus seems to be that the fossils have a position in time which must be very late in the last geologic epoch before the coming of the Recent.

PERIOD	EPOCH	Characteristic Formations in Southern California
Quaternary	Recent	*Alluvium (Land-laid)*
	Pleistocene	*Terrace Deposits (Rancho La Brea)*
		PROFOUND DEFORMATION
		San Pedro (Marine deposits)
Tertiary	Pliocene	*Repetto (Marine deposits)*
	Miocene	*Modelo (Marine and brackish-water deposits)*
	Oligocene	*Sespe (Land-laid)*
	Eocene	*Domengine (Marine deposits)*
	Paleocene	*Martinez (Marine deposits)*

FIG. 4. Geologic divisions of the Age of Mammals showing position of Rancho La Brea.

Outpours of tar have been encountered at Rancho La Brea in which is preserved the life of the Recent or sub-Recent, but these deposits are not to be compared in magnitude with the typical Pleistocene accumulations. Moreover, they contain an assemblage of species in which many of the characteristic elements of the Pleistocene population are conspicuously absent. The presence of pipes, chimneys and pockets filled with tar or asphalt containing the bones of Recent mammals and birds is not unexpected in view of the constant movement of gas and oil to the surface from the oil sands below.

Knowledge of the life of the Ice Age in North America does not include as yet an accurate determination of the life span in geologic time for many species, nor is it possible to state definitely the time of appearance or disappearance of these forms. Much valuable information has been obtained, particularly in the middle west where an attempt is made to establish the position of various Pleistocene organisms in the succession of glacial and interglacial deposits belonging to this epoch. Similar information is almost wholly lacking for the California province, and we may be forced of necessity to seek other

methods in determining the chronological sequence. Furthermore, there is no reason for assuming that the appearance or disappearance of mammalian groups in one region of North America implies the appearance or disappearance of these types at exactly or even approximately the same time in other regions of the continent.

The presence of existing species of plants and animals in the deposits associated with characteristic types of the Pleistocene suggests that the assemblage approximates the Recent to this extent. That it belongs to the last third or probably the last fourth of the Pleistocene rather than to the first half of this epoch is indicated also by the fact that several species identical with Rancho La Brea forms have now been found in deposits of very late Pleistocene or early Recent age in North America. Before these discoveries were made it was generally the opinion that these species became extinct in Pleistocene time. The remarkable state of preservation of a portion of a skull of *Camelops* found in a cave in west-central Utah, and of remains of the ground sloth, *Nothrotherium,* in dry caves of Nevada, Arizona and New Mexico have led several authorities to conclude that these species were living on the North American continent in early Recent time. This suggests, too, that extinction as affecting the animal life of the Rancho La Brea Pleistocene has proceeded into the Recent.

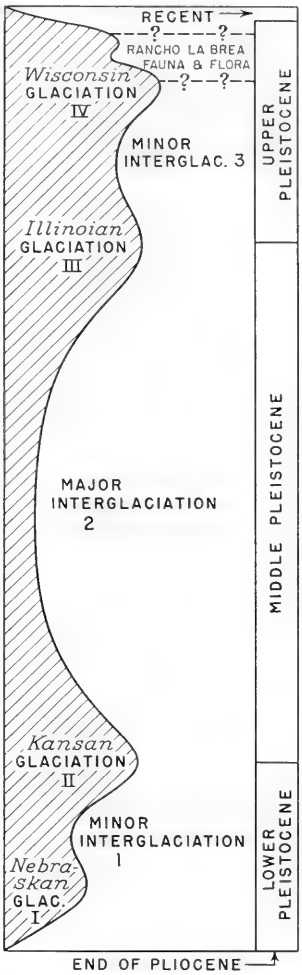

FIG. 5. Diagram showing the glacial and interglacial stages of the Pleistocene with possible position of the Rancho La Brea occurrence indicated in this sequence. Diagram modified after Romer.

It seems desirable to point out some of the difficulties encountered in the study of the problem of age of the Rancho La Brea occurrence, for they emphasize the need of additional investigations before an exact chronological position of this fauna and flora in the Pleistocene sequence can be established.

CLIMATIC CONDITIONS

Conclusions as to the climatic conditions that prevailed during the accumulation of the fossiliferous asphalt are derived in part from a study of the smaller mammals and birds. The plants found fossil at Rancho La Brea are of even greater significance in this connection, since plants are sensitive indicators of climate.

It is of special interest to note that the rodents, rabbits, and shrews are often somewhat circumscribed in range and reflect local conditions. Those that comprise the Pleistocene assemblage belong to species which live today in this region. They suggest, therefore, no great difference in type of climate from that which exists at present in the Los Angeles basin area. Today the desert shrew *(Notiosorex)* ranges through the southwestern states and into southern California. In the asphalt deposits this animal is distinctly more abundant than the adorned shrew *(Sorex ornatus),* which lives in moister areas at the present time.

Similarly, an analysis of the assemblage of small birds, particularly the association of perching birds, has convinced ornithologists that when these creatures were caught in the asphalt the climate was characterized by moderate rainfall and low summer humidity. It was essentially an interior climate featured perhaps by a slight increase in rainfall over the present, and with temperatures similar to or slightly higher than those of today in this region.

The occurrence of many large mammals and birds and the great diversification of the entire fauna may at first glance be taken as a satisfactory basis from which to infer a radically different climate than that of the present. Many of these species, in contrast to those of the rodents and perching birds, are known to have ranged widely over the North American continent and especially through the southwest. It appears probable that with only a slight increase in rainfall a sufficient verdure existed to meet the needs of the herbivorous mammals. It is significant that creatures like the tapir, that live in moist savannahs of the tropics, are very rarely represented in the fossil record at Rancho La Brea. Presence of standing water, and reflecting perhaps local conditions, is suggested by the predominant representation of water insects and bugs, as well as by the ostracods. On the other hand, absence of forms that are associated elsewhere with cold climates, as for example members of the musk-oxen group, suggests that conditions were not rigorous.

Unfortunately, the plant record from the asphalt deposits of Rancho La Brea is not so complete as it might be. However, from the association of plants and more particularly from the common occurrence of juniper, the paleobotanists conclude likewise that the climate was of an interior type, less subject to coastal influences than is the case today (pages 67, 68).

Some of the conflicting evidence on the climatic conditions may be accounted for, as stated in a previous section, if the trapping of the animals and plants continued from within an interglacial stage into a succeeding glacial stage.

PHYSICAL FEATURES AND ORIGIN OF THE ASPHALT DEPOSITS

Until recently no information was available regarding the subsurface strata at Rancho La Brea other than that obtained during the earlier diggings. Test borings at 87 locations within the area of Hancock Park now furnish additional information on the nature of these deposits to a depth of 30 to 40 feet. It is now known, for example, that beneath soil and fill is a yellow clay frequently associated with brown clay and oil-stained sand. Occasionally within the upper 10 feet occurs a blue or greenish blue clay, and the latter deposit is almost always present below the 10 foot level, where it may be a few feet or as much as 10 feet in thickness. In this lower level the blue clay is often associated with bituminous material and permeated by seams of tar. The color of the clay is not always blue, but may be brown or black. At several localities fresh water shells were found immediately above the blue clay.

Almost invariably, typical bituminous sands or asphaltic accumulations were penetrated in the test hole digging beneath the blue clay. The sands occurred between the 20 and 30 foot levels, but extended both higher and lower. They frequently gave way below to coarser deposits. These consist of pebbles and boulders of quartzite and igneous rocks that are subangular and rounded in shape. As a matter of record it should be stated that these relatively shallow test borings revealed no Pleistocene formations containing marine molluscan faunas.

Facts acquired during the diggings by the Los Angeles County Museum more than thirty years ago showed that the bituminous deposits containing fossil bones and plant remains extended upward beyond the 20-foot level, and reached practically to the present surface of the ground. Many of the productive excavations were stated to have closed off in blue clay at the lower level.

It seems clearly evident that the processes responsible for the accumulation of tar beds are today in operation at this locality, although the forces and materials which had led to the special conditions of entrapment are insignificant in contrast to their former magnitude. As indicated before, the source rocks from which the petroleum comes are the oil sands interstratified with the older shales and sandstones that underlie the Pleistocene beds in the region of Rancho La Brea. As determined by the geologic structure (see figure 6) in the Salt Lake oil field, these older marine strata are deformed and folded. Immediately to the north of Rancho La Brea an upward flexure of the older rocks, whose crest has been broken, extends apparently in the NE-SW direction, and without much question facilitates the upward movement of gas and oil in the vicinity of the asphalt beds. Subsidiary underground structures, as for example, local fractures or a minor fold developed in the older sediments, may account for the apparent localization or at least particular representation of the productive brea accumulation at the site of Rancho La Brea.

Presumably the exudation of the petroleum and penetration of the sedimentary strata, forming the tar pools and asphaltic material, occurred concomitantly with deposition of the Pleistocene alluvial accumulation. At the present time oil and gas reach the surface through small fissures, pipes, or chimneys, the oil forming small and generally shallow pools about the vents. Bubbles of gas rise constantly to the surface of the artificial lake and the outpours of oil spread over and through the soil of the adjacent ground. It is interesting to note that occasionally a downward movement of the oil or tar can be discerned at the vents. A temporary release of gas pressure below permits the heavy oil to

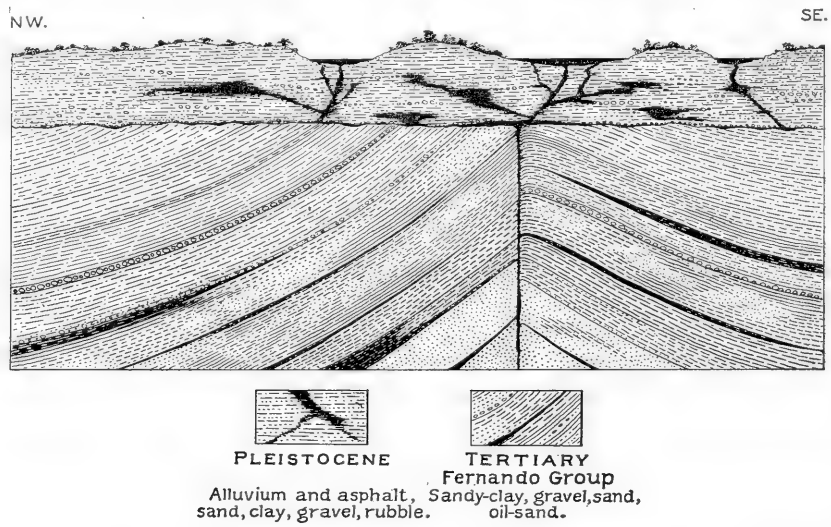

FIG. 6. Generalized cross-section showing geologic structure and relationships of formations at Rancho La Brea during period of miring of Pleistocene animals and plants. Character and structure of the sediments containing the oil sands taken from section in Salt Lake Oil field, modified after Arnold (U. S. Geol. Surv. Bull. 309, p. 189, 1907).

recede again into the pipe or chimney whence it has exuded. The downward flow may carry remains of organisms or hardened lumps of asphalt and other detrital materials from the surface into the pipes. This action is of significance in suggesting perhaps a factor responsible for the movement of submerged animal remains in the larger Pleistocene outpours. When the oil reaches the surface its more volatile constituents escape leaving a denser residue which becomes crusted. This hardening of the surface may occur rapidly along the edges of the pool and may extend gradually inward towards the middle. The surface may remain exposed for some time or may be gradually covered by soil or dust. During certain seasons of the year or during the heat of the day the asphaltic crust becomes quite soft.

During the Pleistocene the exudation of the petroleum was much more extensive than at the present time. The pools of oil which were formed occupied the natural depressions of an irregular land surface and were on occasion many square feet in area. The depth and borders of these pools were probably variable features. Excavations conducted at Rancho La Brea have shown that the fossiliferous asphalt was frequently of irregular outline and varied from relatively shallow accumulations to thick deposits having a maximum depth of 30-35 feet. On the average, however, productive pits extended from a few feet below the surface to a depth of approximately 15-25 feet.

That the outpours of oil and tar contributed to the building up of the land surface is suggested by interesting evidence secured in Pit 3 of the Los Angeles County Museum excavations. Here, at a depth of approximately 4 feet, was first encountered what later

FIG. 7. Example of a "tar volcano" in the Carpinteria Asphalt Mine, near Carpinteria, California. Photograph by Ralph Arnold; courtesy of U. S. Geological Survey.

proved to be an upright trunk of a conifer. The top of the tree had either burned or rotted away. At a depth of 7½ to 8½ feet a large limb projected from the trunk and at a level of 12 feet below the present surface the tree was found to be definitely rooted in a stiff clay. The material surrounding the trunk was clay, sand, and asphalt. Packed also about the limb and portions of the trunk were dense masses of bones and skulls representing

many of the typical mammals and birds of the Rancho La Brea Pleistocene assemblage. There can be little question that the tree occurred *in situ,* growing perhaps originally along the border of a depression in which detrital materials and asphalt were accumulating. Continued exudation of oil may have caused ultimately an encroachment of the asphaltic mass upon the tree with consequent juxtaposition of the entombed animal remains.

It appears possible that not all of the pools were formed as fills in natural depressions occurring at the Rancho La Brea locality during the Pleistocene. Sudden expulsions of large quantities of gas and oil accompanied by sufficient force may have formed in the past crater-like vents many feet in diameter. Presumably the excavations thus created were partially or totally filled by an inflow of viscous material. Moreover the rim of a vent of this type might be elevated somewhat above the general level of the adjacent surface, forming a buttress against which clays, sands, and rubble were deposited. Small crater-like structures are occasionally seen at the present time in the oil fields of California. Arnold (1907b), for example, has figured (see figure 7) a small "tar volcano" in the Carpinteria asphalt mine. Additional information pointing toward this method of formation of a fossiliferous asphalt bed seems to be found in some of the productive fossil pits excavated by the Museum. Contour records apparently indicate in some instances a more or less funnel-shaped mass of asphalt in which fossil remains are preserved.

The visitor to the fossil bearing deposits at Hancock Park must not construe the open "pits," now on view there, as surface features that represent the active traps where animals were caught during the Ice Age. Quite to the contrary, these excavations serve as a record of the explorations for fossil remains conducted, for the most part, some four decades ago.

MODE OF ACCUMULATION OF THE FOSSIL MATERIAL

The small pools of oil or tar now forming at Rancho La Brea are known to catch and hold in their midst the unfortunate creatures who by chance come in contact with the sticky substance. Thus the pools present a unique and most efficient type of trap operating almost unceasingly and capable of catching many of the birds, mammals, and insects now inhabiting the region. Similarly the more extensive Pleistocene outpours, situated in a region richly stocked with vertebrate life, also entrapped animals, but the large size and greater depth of these pools permitted even greater tragedies to occur. It is not difficult to visualize some of these Pleistocene catastrophes. A single animal, large or small, becoming mired in the tar would as a result of its struggles and cries lure others to the trap. The carnivorous birds and mammals seeking to reach this bait would frequently fall victims to the tenacious grip of the viscous material and thus in turn would serve to attract still other creatures to the pool.

It is conceivable that a single pool might gather into its mass in an incredibly short time a great many victims, whose remains now form the remarkable accumulation of bones, skulls and teeth found at Rancho La Brea. That the carnivorous types were ever ready to yield to temptation in a desire to reach the prey fastened in the tar and were therefore particularly susceptible to entrapment and subsequent entombment is clearly attested by their preponderant representation. Attention has been directed to the occurrence of many remains of young, aged, and maimed individuals. Doubtless the age of the animal, its keenness in sensing danger, and its ability to secure food in and away from the traps are but a few of the factors contributing to the uniqueness of this type of accumulation.

NATURE AND PRESERVATION OF THE FOSSIL REMAINS

Without much question the peculiar character of the embedding material, a heavy oil or soft tar in some instances, or frequently a granular asphalt, has been largely re-

FIG. 8. Typical excavation at Rancho La Brea showing exposure of skulls and bones of Pleistocene animals in the asphalt. Note skull of wolf near top, jaws of bison at middle, and hip bone of large ground sloth at bottom. Photograph by John C. Merriam.

sponsible for the excellent preservation of the animal and plant remains. Seldom, indeed, are conditions found so favorable for the reconstruction of a life record of the past. To be sure, the softer animal tissues have disappeared, and we are therefore dependent upon the structure of the harder parts, as for example skulls, teeth, and bones, for an identification of the various forms.

Specimens of mammals and birds are particularly well represented, the various skeletal elements and skulls of these types forming not infrequently thickly matted accumulations as shown in figure 8. The distribution of these deposits is usually irregular, the masses of bones occurring as pocket-like concentrations in the asphalt. Merriam states that in a mass comprising less than four cubic yards, a careful count indicated the presence of more than 50 heads of dire wolf, at least 30 skulls of the sabre-tooth cat, and numerous remains of bison, horse, sloth, coyote, birds, and other forms. Reptiles and amphibians are only sparsely represented. Insect remains occur, and are commonly found in some deposits. The record of the plants is rather limited as to species and the material consists principally of pieces of wood. In addition, leaves, cones, and seeds have been found.

Skulls, teeth, and skeletal elements found at Rancho La Brea have come down through time practically unchanged from their original state. During the period of entombment the investing substances have found their way through the hard layers of the bones and teeth. Save for a thorough penetration by the oil and a prevailing black or brown color imparted to the bone, little difference in state of preservation is noted between this material and that of modern forms. Oil or tar may accumulate in quantity in the remote sinuses of skulls or in the marrow cavities of the long bones. The brain and nasal cavities of skulls are filled with asphalt which frequently has carried into these chambers the osseous remains of small mammals and birds. The soft matrix has likewise held intact the largest as well as some of the smallest bones. It is interesting to mention that from some mammalian skulls have been recovered the tiny bones of the inner ear. Teeth are generally well preserved and often retain the evidences of wear to which they were subjected in life (see figure 9). Limb elements exhibit not only the form and manner of articulation with adjacent bones but also many surface markings showing the courses of nerves and blood-vessels and the place of attachment of important tendons and ligaments.

Injured and diseased bones and teeth occur in the collections. Fractured bones that have healed in life are found among the mammalian and avian remains. Bone lesions due to pathological disturbances other than those arising from fractures are not uncommon. Materials displaying the characters of wear and disease emphasize the reality of the organic remains from the asphalt and point unmistakably to the fact that they were parts of once living creatures.

Curious as it may seem, the epidermal structures of vertebrates are not preserved. Thus, no preservation has been noted of hair or feathers, of the strong, horny nails or claws in mammals, or of the horny beaks and talons in birds. On the other hand, parts of the chitinous bodies of insects are present in the asphalt. Wood found at Rancho La Brea has a remarkably fresh appearance and, as may be expected, burns readily. Cones of pine and cypress have been thoroughly impregnated by the oil and exhibit their structures in considerable detail. Occasionally leaves are found, but more often only the impressions remain, in which however the details of the venation can still be discerned.

Frequently parts of an individual skeleton are associated in the asphalt, although movement in the mass has tended to shift the bones laterally and vertically. It appears not improbable that in some instances a fairly complete skeleton occurred within a radius of relatively few feet. Moreover, with the exposure of bodies at the surface of a tar trap it seems fair to assume that these were dismembered and that parts, strewn about on the ground adjacent to the borders of an active pool, were damaged, destroyed or devoured before submergence in the tar preserved the remains. Subsequent movement of the osseous material is apparently indicated by what has been termed "pit wear." The larger bones occasionally exhibit grooves or cuts which apparently cannot be ascribed to the work of predatory beasts. The abrasions may be deep and in some specimens have nearly sheared an individual bone in two. Specimens are known in which the outer surfaces are almost entirely destroyed by such wear.

In contrast to these specimens, skeletal elements in the collections exhibit surface effects clearly due to attrition by organic forms, presumably carnivores and rodents. Relatively large abrasions have been noted in which chips of bone an inch or more in length have been flaked off or broken away. Apparently in some cases the bite has been strong enough to expose the marrow cavity. Small abrasions also occur, usually in the form of grooves approximately one-sixteenth of an inch in width, and sometimes parallel. An individual groove may show on closer inspection minute transverse ridges representing stages in the production of the groove by the chisel-like edge of the incisor teeth of rodents. Occasionally the two types of marking are superimposed. It is apparent also that the mammals intent upon breaking or gnawing a particular bone found a convenient grasp along the more pronounced borders, for the latter are often scarred. Skeletal remains exhibiting these features may have furnished a source of food coveted particularly by the strong-jawed carnivores and by the smaller gnawing forms.

FIG. 9. Superior view of lower jaw of the large dire wolf *(Canis (Aenocyon) dirus* (Leidy)). Specimen belonged to an old animal in which the teeth were considerably worn during the life of the individual. Los Angeles County Museum collection; Rancho La Brea Pleistocene.

The exposure of mammalian materials for any length of time at the surface of a tar pool, or in its immediate vicinity, is indicated not only by the markings left by other mammals, but also by the type of preservation of the compact bony tissue of the skull and skeletal elements. The osseous remains usually retain their smooth external appearance.

In some instances, however, the material exhibits quite strikingly the effects of weathering, and although the specimens are now thoroughly penetrated and stained by the oil, they possess a surface appearance so closely similar to that of weathered skeletal remains found

FIG. 10. Lateral views of upper arm bone of dire wolf *(Canis (Aenocyon) dirus* (Leidy)). Figure on left, specimen showing a healed oblique fracture with an abnormal bone growth; figure on right, a normal specimen of the same bone. Both to same scale. Los Angeles County Museum collection; Rancho La Brea Pleistocene.

lying on the plains at the present time as to fully justify the recognition of similar conditions before these objects were finally covered by the tar.

The entomologist has discovered further pertinent facts relating to the preservation of organisms at Rancho La Brea. Fossil insect remains are found in the asphaltic fillings of cavities of skulls and limb bones belonging to extinct animals. An interesting case in point is that of a broken end of an upper arm bone of the great condor-like vulture *(Teratornis)* in which were found, nestled among the cellular parts of the walls bounding the pneumatic (marrow) cavity, a number of puparia of a blowfly. The fly responsible for these larvae or larval cases, obviously deposited while the bird bone was still comparatively "fresh," is known to be related to the black blowfly and to the screw-worm fly. As one of the ubiquitous organisms to be expected in the presence of death and during putrescence, this bit of evidence is graphically revealing. As a matter of fact, certain insects preserved in the tar are near relatives of kinds that today are present and characteristic of individual stages which mark the long cycle of disintegration that a dead body undergoes. It mutely demonstrates that ultimate entombment of remains at Rancho La Brea was at times a comparatively slow process (see page 67). It likewise points to the existence, perhaps prevalence, of offensive odors in and about the tar traps during their active period.

OCCURRENCE OF HUMAN REMAINS

Portions of a human skull and associated skeletal remains were encountered by the Los Angeles County Museum in the course of excavations in pit 10 at a depth extending from approximately 6 to 9 feet. The remains occurred in one of two pipes or chimneys arising from an asphaltic reservoir below and connecting with a surface flow above. The material filling the pipe consisted of a viscous mass containing sand and the hardened lumps of weathered asphalt. Presumably the material was in part derived from below and in part from above. The human remains belonged to one individual and are clearly those of a modern type. Judging from the structural features of the skull this individual possessed racial characteristics not unlike those of the aboriginal people known to have lived on the Channel Islands and in the coastal province of Southern California prior to the advent of the white man. Merriam (1914) concluded from a preliminary study of the human find that "the age of this specimen may perhaps be measured in thousands of years, but probably not in tens of thousands."

Possible association of man with the condor-like vulture *(Teratornis)* and proximity of the human material to the rich Pleistocene life found at this locality gave the occurrence special significance. The bird and mammal assemblages found in association with the human remains in pit 10 furnish evidence of the degree of antiquity of the occurrence. Howard and Miller (1939) conclude from a study of the birds that: "Looking at the avifauna of pit 10 as a whole, we find here an important link between the typical Pleistocene and the typical Recent. Nine of the sixteen extinct species associated with Pleistocene Rancho La Brea are present in pit 10, but all are so reduced in numbers as to be only one-tenth as abundant as they were in the Pleistocene. We see in this assemblage, then, an intermediate stage in the extinction of birds usually considered to be typically Pleistocene. The avifauna as a whole, however, resembles that of the Recent more closely than that of the Pleistocene. Therefore, if a line is to be drawn between these periods, pit 10, in which the *Homo* remains were found, should fall into the Recent."

Similarly, the associated mammals are for the most part types more characteristic of the present rather than of the Pleistocene. There are no indications of presence of the

formidable carnivores so well represented in the typical Pleistocene asphalt at Rancho La Brea, and among the herbivores only a horse is recorded. It has not been shown that this species is identical with the Pleistocene *Equus occidentalis.*

FIG. 11. Two views of tibia or shin bone of the great cat *(Panthera atrox* (Leidy)) showing tooth marks left by carnivores and rodents. Los Angeles County Museum collection; Rancho La Brea Pleistocene.

Indication of man's presence at Rancho La Brea is not limited to the evidence encountered in pit 10, for scattered materials of human origin have been uncovered in some of the diggings from which the more ancient brea fauna has come. This is particularly true for pits 61 and 67, whence have come a wooden bunt foreshaft for an atlatl dart and three broken atlatl dart foreshafts. These specimens are recorded as coming from a depth extending from 8 to 18 feet beneath the surface. Woodward (1937) calls attention to the fact that these specimens are heavier and of cruder workmanship than those discovered by Harrington in Gypsum Cave, Nevada. Woodward states further that the presence of the foreshafts in the Rancho La Brea deposits indicates that an atlatl-using people once inhabited or at least penetrated into Southern California and possibly were contemporaneous with animals now extinct but which are found in the brea.

FACTORS INFLUENCING GROUP REPRESENTATION AMONG THE MAMMALS

The most striking feature of the Rancho La Brea mammalian assemblage is the preponderant number of predatory forms. In this single character the fauna differs noticeably from existing or extinct assemblages that frequent the plains today or that have lived in open country, where the balance between carnivores and herbivores has not been materially disturbed. Without much question this peculiarity of the Rancho La Brea fauna is a direct result of the effective lure offered by victims mired in the tar traps, which brought the flesh-eating mammals particularly to the pools.

A census taken of the Pleistocene mammals represented in the collection of the Los Angeles County Museum, reveals a total number of more than 4,000 individuals. By far the larger number of animals comprising this population are carnivores. In contrast, the herbivores or plant-feeders form a distinctly smaller number. Figure 12 graphically illustrates the relative size of the various orders of Rancho La Brea mammals. Among the Carnivora the largest number of individuals is included in the canid or dog family, with the cats forming the next largest group. The dogs constitute approximately 57 per cent of the carnivore population, the cats 40 per cent. Each of these families greatly exceeds in number the bears and mustelids. The raccoons are conspicuously absent. Among the plant-feeders, the family having the greatest number of individuals is the Bovidae. Then follow in turn the horses (Equidae), mylodont ground sloths (Mylodontidae), camels (Camelidae), antelopes (Antilocapridae), mastodons (Mastodontidae), and deer (Cervidae). Lastly come the peccaries (Tayassuidae) and tapirs (Tapiridae). The Insectivora are not numerically conspicuous. On the other hand, other small mammals like the rodents are doubtless abundant, though of somewhat limited variety. Unfortunately, we have as yet little to go on in reaching an estimate of the actual number of gnawing animals that were caught in the tar.

In those mammalian families which include extinct forms as well as species that have carried over their existence from the Pleistocene into Recent time, the extinct forms are always represented by a greater number of individuals. In other words, the typical Pleistocene species in the Rancho La Brea fauna are relatively more important elements in this assemblage than those types which are characteristic of the Recent period, but whose range extends also in the Pleistocene. Thus, within the dog family the number of dire wolves is far in excess of that of the coyotes and gray wolves. The modern gray fox is known by only a few individuals. Among the cats the sabre-tooth, a creature now extinct, is much better represented in the fauna than the great lion-like feline. The latter, while

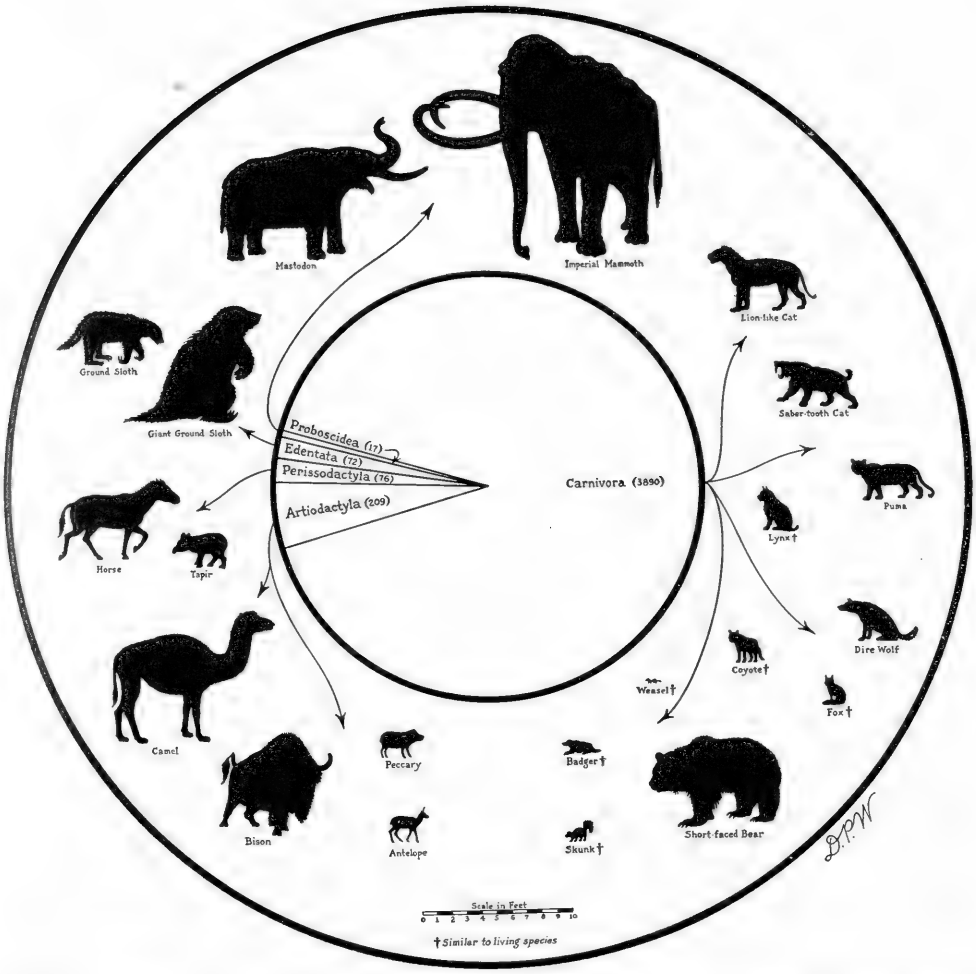

FIG. 12. Diagram illustrating relative number of individuals in the mammalian orders (except rodents, lagomorphs, insectivores, and bats) occurring in the Rancho La Brea Pleistocene fauna. Note preponderance of predatory forms.

specifically different, is still closely related to some of the large living cats. Both the sabre-tooth and the lion-like cat greatly exceed in numbers the puma and the lynx. Among the bears the tremarctotheres, or short-faced bears, are twice as abundant as individuals of the black bear-grizzly bear group. Among those hoofed mammals that permit a similar comparison the same relationship is evident. Within the antilocaprid family, for example, an extinct type *(Breameryx)* forms numerically a decidedly more important group than the pronghorn.

The relative abundance of kinds of Pleistocene mammals, whose descendants have not come down to the present day, is in a measure an index of the antiquity of the assemblage. In other words, the position of the Rancho La Brea fauna in geologic time is suggested by the presence of many typical Pleistocene mammals, for the element of time is an important factor in determining the constitution of such an assemblage. Were this fauna actually of the Recent epoch rather than of the Pleistocene, its position would

unquestionably be indicated by a noticeable decrease in the number of typical Pleistocene mammals and by an increase of those forms that are characteristic of the Recent.*

In addition to the element of time, the determining factors that exert an influence on the presence or absence of different kinds of mammals are found in the environmental conditions and in the habits of the animals themselves.

The conditions which prevailed in the immediate vicinity of the asphalt accumulations and the availability of food are reflected by the extraordinary numbers of dire wolves and sabre-tooth cats. The dire or grim wolves undoubtedly preyed upon the large, cumbersome, and slow-moving mammals with which they were associated. It appears probable that in a broad way these animals occupied a niche in the North American animal world of the Pleistocene like that held by the hyaenas in the life of South Africa and Asia today. The tar traps, with their living hosts and partly devoured, dismembered carcasses, doubtless offered very suitable feeding grounds for these types.

The sabre-tooth, in contrast to the great lion-like cat, was certainly not a predatory form dependent upon its fleet-footedness in hunting its prey. This is clearly indicated by the fact that the lower segments of its limbs (the two bones of the forearm and those of the foreleg) are distinctly shorter than in a typical running form like the lion. The sabre-tooth exhibits rather an organization admirably adjusted to grappling and fighting at close quarters. Truculent to the extreme, this creature found its victims among the slow-moving mammals and the stationary live bait of the tar traps. The unfair advantage which the sabre-tooth cat possessed around the borders of a brea seep was apparently compensated only by its own high mortality.

That the country surrounding the asphalt deposits presented topographic features essentially similar to those which characterize the Los Angeles area today is suggested by the mammalian assemblage as a whole and apparently also by the geologic history of the region. The climate may have been as equable as it is today, with only slightly greater precipitation and somewhat lower humidity. A plain, or open rolling country on which grew an interior, semi-arid type of vegetation, and where grass-covered surfaces were interspersed with copses of trees and brush, seems to have favored the existence of a diverse population of hoofed mammals. In this environment such types as the bison, horse, mylodont ground sloths, elephants, camels and antelopes would normally be found. Associated with these herbivores were typical cursorial carnivores like the lion-like cat and the coyote. As important members of the community should be listed, of course, the dire wolves and the sabre-tooth cats. One might regard this assemblage as the resident population.

In contrast to this group are those forms which did not live habitually in the region, but which occasionally penetrated it from adjacent areas. This assemblage includes species that are only sparsely represented at Rancho La Brea. Among these are the megalonychid ground sloths with browsing habits, the timber wolves, peccaries, deer, and mastodons. Perhaps, as suggested in a previous section, the presence of these animals may be accounted for by their arrival on the scene at a slightly different time than that when the plains-dwelling mammals were the typical inhabitants of the region.

The region seems to have been sufficiently wooded or covered with brush to afford shelter to a number of diminutive antelopes *(Breameryx)*. These animals may have occu-

*The recent fauna is an outgrowth of that of the Pleistocene. The lack of great diversity of type at the present time is largely, but not entirely, due to the extinction of many of the older forms. Exact information as to time of disappearance of these earlier types is of great importance in determining the position of Rancho La Brea in the chronological events of the later Pleistocene, but we are here not especially concerned with this problem (see pages 13-17).

pied a niche in the environment somewhat like that in which the dik-dik and duiker antelopes of South Africa are found today. *Breameryx* perhaps emerged from cover at dusk to feed.

It is a curious fact that members of the raccoon family are not at all recorded among the Pleistocene mammals found in the brea beds. That these forms were absent in the Los Angeles region seems rather unlikely. Th raccoon has been recorded in the Pleistocene of California and its range at the present time extends into this southern area. Possibly the extreme wariness of this mammal may account for its absence in the asphalt.

Small ponds and streams probably were present in the immediate vicinity of the asphalt beds during Pleistocene time. These apparently served as one of the attractions of the region. Animals coming to the region to drink waded into the water and were mired in the asphalt beneath. It is evident that in the instance of some brea occurrences the presence of water brought to these specific sites a considerable number of water birds. However, a comparison of the environment at Rancho La Brea during the Ice Age with that about a water hole on the African veldt today does not seem to be entirely warranted. It would appear unnecessary to assume, because of the large number of trapped animals, that the surrounding area was as devoid of water as are the drier parts of the veldt at the present time. On the contrary, it is quite probable that at no great distance away were streams, as for example the predecessor of the present Los Angeles River. These, even during the driest seasons, may have had a sufficient flow of water to sustain the animal life of the region.

CONSIDERATION OF INDIVIDUAL GROUPS OF MAMMALS

INSECTIVORA (Shrews)

Two species of shrews are the only representatives of this group which have thus far been recognized in the Rancho La Brea collections. A few bones have been referred to the adorned shrew (*Sorex* cf. *ornatus* C. H. Merriam), which is the only long-tailed shrew now living in the region. Remains of the desert shrew (*Notiosorex crawfordi* Coues) are fairly abundant, outnumbering the preceding species ten to one. Regarding this form, Compton (1937) remarks: "The occurrence of this shrew at Rancho La Brea offers an interesting comparison of its distribution during Pleistocene times with that of today. At present this species is restricted to the southwestern states, and is considered rare. The farthest north that it has been taken in California is at Colton, Riverside County. Most of the specimens have come from San Diego County (Grinnell, 1933, p. 85). None has been taken in Los Angeles County, nor in Orange County which lies to the south of it. It would appear, then, that *N. crawfordi* either ranged farther north and west along the Pacific slope during the Pleistocene, or that our knowledge of its modern distribution is incomplete."* The relative abundance of the desert shrew tends to substantiate the theory that the climate in the Los Angeles area during the active period of the brea traps was slightly drier and hotter than it is at present.

CARNIVORA

Canidae (Wolves, Coyotes, Foxes)

Individuals of the canid or dog family are the most commonly occurring mammals in the Rancho La Brea assemblage. No other group of carnivores is represented by so great

*This shrew has been trapped recently in southern Santa Barbara County by Jack C. von Bloeker, Jr., (personal communication).

a number of individuals, although the cats make a close approach in this respect. The dogs from the asphalt deposits were described in detail by Merriam (1912).

An unusual feature of this group is the large representation of the dire or grim wolves *Canis (Aenocyon) dirus* (Leidy). These forms were presumably very wide-spread over the North American continent during Pleistocene time, for their remains have been encountered at a number of fossil localities. Originally described from Pleistocene deposits in the Mississippi Valley, the dire wolves have since been recognized as far east as Florida and as far south as southern Nuevo Leon and the Valley of Mexico. In addition to the occurrence at Rancho La Brea, records of their presence in California have been found in Pleistocene deposits of Livermore Valley, in beds of similar age along the border of the San Joaquin Valley, at McKittrick and Carpinteria, and at San Pedro.

Canis (Aenocyon) dirus, shown in figure 13, is a large species of wolf, approximately 8 per cent smaller than the largest known representatives of the northern timber wolf living, for example, in northern Alberta, Canada. *Canis (Aenocyon)* was, however, larger than the timber wolves that are found today at more southerly latitudes in North America. In either case, the external appearance and habits of the extinct and living species must have been quite different.

Canis (Aenocyon) had a large and heavy head, a relatively small brain, a massive dentition, as well as large shoulder blades and pelvis. The very strong jaws and teeth furnished a powerful biting mechanism capable of crushing large bones. It appears not unlikely that the dire wolf resorted occasionally to carrion for food.

Differences in appearance must have existed between the dire wolf and the timber wolf as a result of the proportions of front and hind limbs and of particular limb segments. In the extinct wolf the foreleg is shorter than the hind leg, albeit the difference is small. In addition, the lower segments of the limbs in the dire wolf, particularly in the hind limb, are shorter relative to the length of the upper segment (upper arm bone and thigh bone) than in the timber wolf. These differences may be construed to signify that the former animal was not so fleet of foot as the latter.

Merriam (1912) has remarked concerning the habits of these creatures as follows: "The form of the skull suggests that the head was normally held low and was often used in hard pulling and hauling of heavy bodies. The great number of individuals of *C. dirus* found at Rancho La Brea suggests that the wolves of this species sometimes associated themselves in packs, and that groups of considerable size may have assembled to kill isolated ungulates and edentates. Particularly the young, aged and injured, when they could be separated from their associates, would be the natural prey of the great wolf, but adults in normal strength may also have succumbed to the combined attack of several of these powerful animals."

As in the case of the sabre-tooth cat, the collection of bones of this wolf includes a number of specimens showing fractures and abnormalities in bone growth. Luxations were probably due to injury (see figure 10, page 25) and were followed by chronic infection in several instances.

Associated with the dire wolf although occurring much less frequently was another member of the *Aenocyon* group. This form, described as *Canis (Aenocyon) milleri* (Merriam) and as yet recognized only by skull material, differs in certain structural characters of the skull and dentition from the typical dire wolf.

In contrast to the hundreds of individuals of the dire wolf are the very limited number of canids related rather closely to the modern gray or timber wolves. Only eight specimens have been recognized in the Museum collections. A skull from Rancho La Brea in the collection of the University of California has been used as the type for the extinct species, *Canis furlongi* (Merriam).

The coyotes rank next to the dire wolves in number of individuals found in the asphalt, although they are only one-tenth as numerous. The coyotes are known principally by one species *(Canis orcutti* (Merriam)), perhaps directly ancestral to, and certainly closely similar in structure to the coyote *(Canis latrans ochropus* Eschcholtz) which occurs today in the Los Angeles area. Another type, known by a single skull in the University of California collection, differs from the existing coyote in possessing a relatively short and broad muzzle. This coyote-like wolf has been described as *Canis andersoni* Merriam. Still another specimen belonging to this group is *Canis petrolei* Stock, but the validity of the species is in doubt.

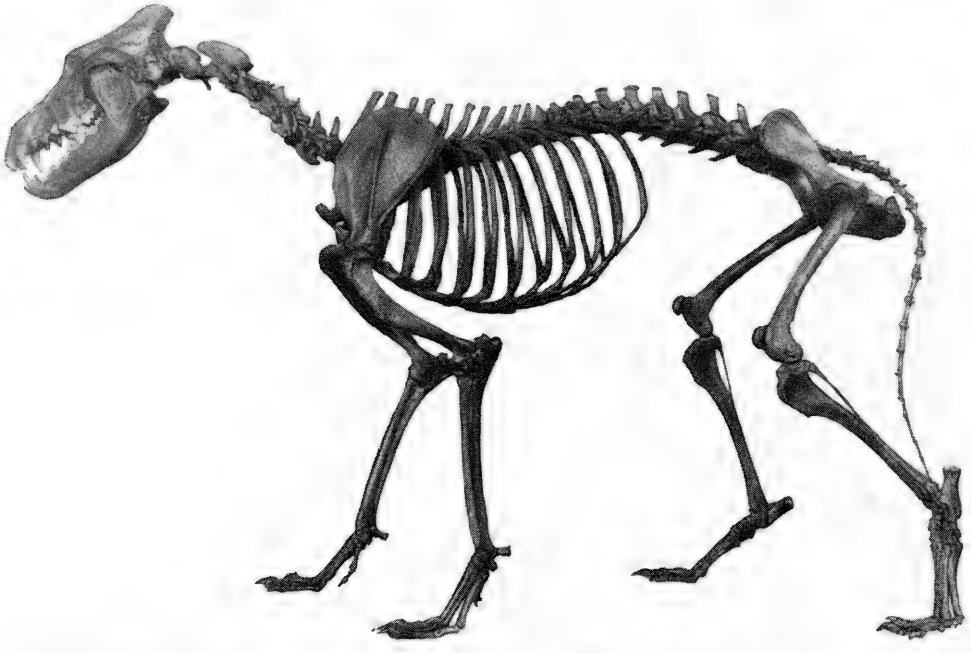

FIG. 13. Skeleton of large dire wolf *(Canis (Aenocyon) dirus* (Leidy)). Los Angeles County Museum collection; Rancho La Brea Pleistocene.

The presence of many coyotes at Rancho La Brea is presumably due in large measure to the prevalence of their natural prey, namely, small mammals and birds held captive in the tar or hovering about the tar pools. In contrast to the dire wolves the decidedly smaller representation of the coyotes may be accounted for by assuming a less frequent occurrence of these carnivores in the vicinity of Rancho La Brea during the period of accumulation of the asphalt beds. On the other hand, it may be due to a greater intelligence which aided these creatures in avoiding the dangers of the petroleum traps. With the passing of the Pleistocene and the extinction of the dire wolves, the coyotes established themselves as an important group of carnivores in the region.

A gray fox identical with the modern species *(Urocyon californicus* Mearns) is also recorded. The desert kit fox *(Vulpes)* is absent, although it occurs in the asphalt at McKittrick.

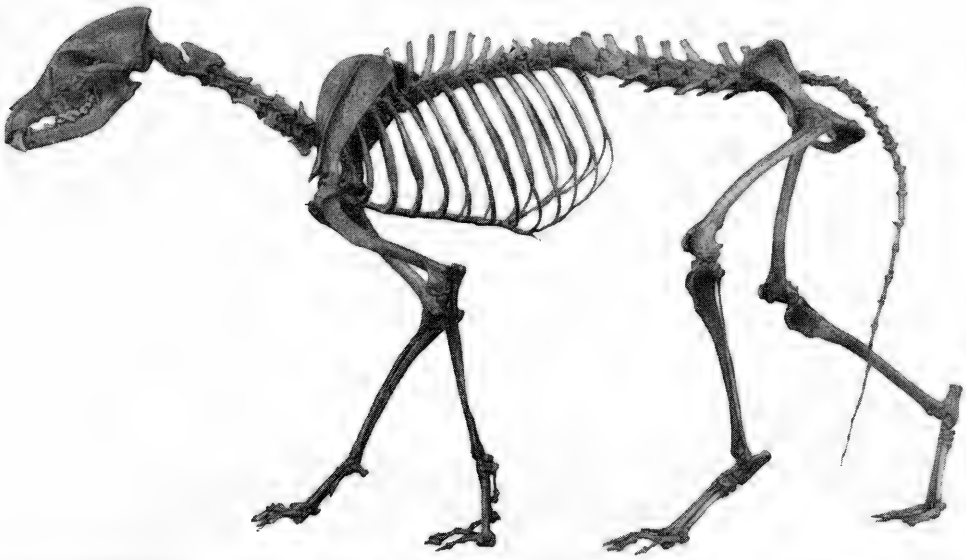

FIG. 14. Skeleton of extinct species of coyote *(Canis orcutti* (Merriam)). Los Angeles County Museum collection; Rancho La Brea Pleistocene.

Ursidae (Bears)

Among the bears discovered in the fossil record of Rancho La Brea three distinct types are recognized. Of special interest are the tremarctotheres or short-faced bears *(Tremarctotherium simum* (Cope)). This form differs in a number of structural characters from the living bears of the North American continent (see figure 15). The tremarctotheres, in contrast to the black bears, possessed a shortened face as indicated clearly by the skull and by the somewhat crowded front cheek-teeth. Moreover, while the number of teeth in the upper and lower jaws is similar to that in existing bears of North America, the carnassial or principal cutting teeth (upper premolar 4 and lower molar 1) are somewhat more like those in typical carnivores like the dogs than are the corresponding teeth in bears of the grizzly or blackbear type. Doubtless the tremarctotheres were more carnivorous in their habits than were the true bears. These forms are characterized also by very large size, in which respect they resemble the great brown or Kadiak bears of the coastal region of Alaska. They were undoubtedly the largest flesh-eating mammals occurring at Rancho La Brea.

The tremarctotheres enjoyed an extensive distribution over the North American continent in Pleistocene time, for remains of these creatures have been found in the Yukon, in Pennsylvania, Kentucky, and Texas, and at a number of localities in California. They or their close relatives were also widely distributed in South America during the Ice Age. This group of bears, while now entirely extinct, is more closely related to the spectacled bear of the South American Andes than to any living North American type.

The true bears are represented in the Rancho La Brea fauna by a black bear *(Ursus optimus* Schultz) and by a grizzly *(Ursus horribilis* Ord). These forms are closely related

to types now living in the California region, or existing here during the historic past. The fossil black bear possessed relatively large grinding teeth, in which character it differs specifically from its living relatives.

Within the bear family it is interesting to note that those forms most closely related to types now living in California were distinctly outnumbered by bears of a kind now extinct. With the disappearance of the tremarctotheres, however, the black and grizzly bears established themselves as the prevailing representatives of the family in California. The grizzlies have since become extinct in this region.

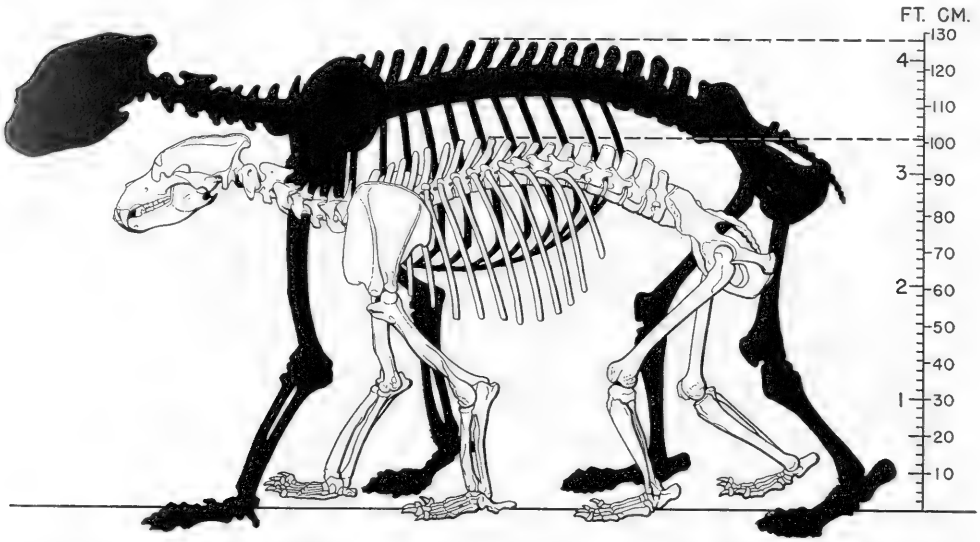

FIG. 15. Comparison of the skeleton of the Pleistocene short-faced bear *(Tremarctotherium simum* (Cope)) from Rancho La Brea in silhouette, with that of the Recent but extinct California grizzly *(Ursus horribilis* Ord) in outline. Note great difference in size.

Mustelidae (Skunks, Weasels, Badgers)

The smaller carnivorous mammals of the Pleistocene of Rancho La Brea, particularly those of the mustelid family, are, like the rodents, closely related to living members of the group. Pleistocene mustelids of the western part of the United States, however, tend to be somewhat larger than their modern representatives. It is not surprising to find recorded in the asphalt the striped skunk *(Mephitis mephitis holzneri* Mearns), spotted skunk *(Spilogale phenax microrhina* Hall), weasel *(Mustela frenata latirostra* Hall), and badger *(Taxidea taxus* cf. *neglecta* Mearns), in view of the habits of these animals at the present time. The weasel, represented by 53 skulls, is by far the most abundant member of this family in the asphalt.

The predaceous skunks and weasels feed on small mammals and birds. The prevalence of the latter forms in and about the asphalt traps undoubtedly accounts for the presence of their natural enemies. The badgers, with food habits somewhat like those of the skunks and weasels, are fossorial. It appears not improbable that in some instances these mammals were trapped in their burrows during the exudation or outpouring of the tar. On the other hand, badgers are known to move about considerably over the surface of the ground and may have floundered on occasion into the petroliferous material.

Felidae (Cats)

The cat family as recorded in the asphalt includes representatives of both the sabre-tooth and true cat groups. Perhaps the most unusual type in point of specialization is the sabre-tooth (*Smilodon californicus* Bovard). This form ranks next to the dire wolf in number of individuals found in the tar pools and greatly outnumbers all other types of cats.

The sabre-tooth approximated in size the African lion, although the body and limbs were somewhat differently proportioned. In *Smilodon* the hind limbs are relatively light while the front limbs are strong and powerful extremities. This sturdiness and strength is likewise shown by the rib basket and breastbone. The lower segments of the limbs are relatively short in comparison to those in the great extinct lion or jaguar. It becomes apparent from an analysis of the structural features that these creatures were not fleet-footed carnivores like the lion or tiger. On the contrary they probably preyed on the larger and more slow-moving mammals with which they were associated during Pleistocene time. A curious feature is the short tail, in which respect *Smilodon* exhibits a superficial resemblance to the lynx or bob-cat.

Fundamental differences between the sabre-tooth and the lion or puma are perhaps most strikingly shown in the skull and dentition. *Smilodon* possessed a relatively small brain and was doubtless a more savage or truculent beast of prey than either the lion or the puma. The skull is curiously modified in adjustment to the great development of the dagger-like canine teeth in the upper jaw. Some of these modifications should be mentioned.

The external nasal opening has receded somewhat from its normal position seen in typical cat skulls. The hard palate develops rather prominent bony ridges which run the length of this surface. In the ear region the sabre-tooth skull exhibits a remarkable character in the growth of the mastoid, furnishing thereby a greater area for attachment of muscles exerting a strong downward pull on the head. Certain parts of the lower jaw, in contrast to those in the true cats, are weakly constructed. Judging from the development of structures to which important muscles were attached, the lower jaw swung through a wide angle when the mouth was opened in attack, and the biting strength of this element was correspondingly weakened.

The dental battery of the sabre-tooth presents some rather unusual specializations. In this cat the dentition of an adult individual usually consists of 26 teeth, while in the lion or puma 30 teeth are present. In other words, the sabre-tooth has lost a front premolar tooth on each side of the upper and lower jaw that is present in the true cats. The upper canines are great dagger-like teeth, considerably elongated in their long curvature and flattened transversely. The front and back edges of the crown of the canine are minutely serrated. *Smilodon* literally means sabre-tooth, a name well applied to this cat. The lower canine teeth are reduced in size and resemble in this character and in shape the lower incisors. In the cheek-tooth region the principal cutting teeth have their blades compressed transversely and lengthened in fore and aft line in adjustment to a cutting or slashing action.

In attacking a large mammal like an elephant, mastodon, or ground-sloth, the sabre-tooth cat would probably seek a vulnerable spot on the body or neck of its prey, grip the victim with its powerful front limbs and claws and repeatedly stab with the upper canines, thus inflicting a jagged wound. In this attack the lower jaw was capable of swinging

downward giving a considerable gape to the mouth, the powerful head and neck muscles furnishing at the same time a strong thrust which accompanied the stabbing action of the teeth. The backward position of the nasal opening presumably permitted the animal to breathe with head plunged deeply into the side of its victim, and the presence of a strongly corrugated gum covering the ridges of the hard palate may have rendered service in blood-sucking.

FIG. 16. Lateral view of skull of sabre-tooth cat *(Smilodon californicus* Bovard). Los Angeles County Museum collection; Rancho La Brea Pleistocene. After Merriam and Stock.

A curious feature noted in an examination of the great collection of skeletal remains of the sabre-tooth cat is the relatively high frequency of lesions in particular elements. While pathological disturbances of the normal structure are occasionally noted in the skull and dentition, they are particularly evident in the limb bones and in the lumbar

region of the vertebral column. Moreover, while fractures which have healed during the life of the individual are to be found in a number of bones of mammals and birds from the asphalt, abnormalities in bone growth were apparently rather prevalent among the sabre-tooth cats. According to Dr. R. L. Moodie who gave considerable attention to the study of the diseases affecting Rancho La Brea mammals and birds, most of the pathological conditions are to be attributed to injury with subsequent infection. Furthermore, cases of luxation and arthritis have been recognized. It is perhaps not surprising to find disturbances of the normal bone growth in creatures as savage as the sabre-tooth cat and dire wolf. Injuries were doubtless inflicted frequently in the combats that transpired when large numbers of these beasts gathered about the tar pools.

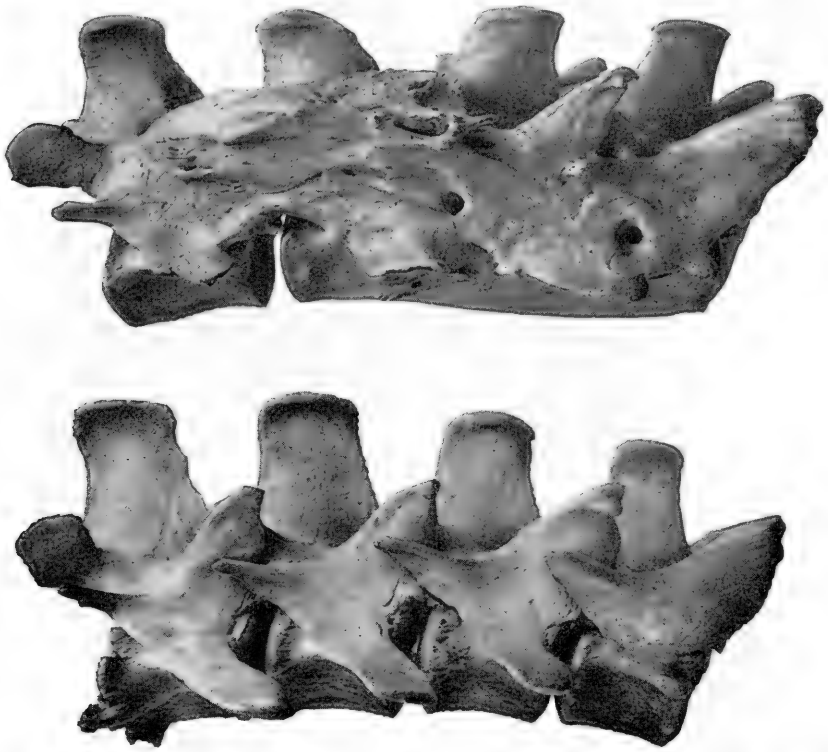

FIG. 17. A series of four anterior lumbar vertebrae of the sabre-tooth cat *(Smilodon californicus* Bovard). Upper figure, fused vertebrae with ossification of the lateral muscle mass; lower figure, a series of corresponding vertebrae in which the segments have not coalesced. Los Angeles County Museum collection; Rancho La Brea Pleistocene.

Less evident are the causes which have contributed to the occurrence of abnormalities in the vertebral column of *Smilodon.* In the lumbar region, particularly, two vertebrae or as many as four may fuse to form a more or less solid tube due to the development of excess bony tissue along the sides and bottom of the vertebral series (see figure 17). This malady resembles a pathological state occurring in Man in which a progressive ossification or formation of bone takes place in the muscle tissue lying adjacent to the lumbar vertebrae. Whether or not the peculiar habits of these creatures were in a measure responsible for this unusual fusion has not been determined, but the condition remains as one strikingly characteristic of this group of predatory beasts.

Occasionally skulls of the sabre-tooth are encountered in the asphalt in which one or both of the sabre-like teeth were broken in life, an injury sustained apparently during combat. In such specimens the broken edge of the sabre exhibits a worn and smooth surface, clearly denoting the fact that the cat subjected the tooth to use after injury occurred. Not only is this evident but the cheek-teeth also frequently show excessive wear, suggesting that the animal found greater need for these teeth after loss of the canines. Quite obviously such individuals were at a decided disadvantage in their struggles for existence.

The sabre-tooth cats have had a long and eventful history in the course of geologic time, the first record of their presence being found at an early stage of the Age of Mammals. The last members of the group are found in the Pleistocene. Sabre-tooth cats closely related to the Rancho La Brea species have been recorded in Florida, Nebraska, Texas, and Mexico, and similar forms are known from the Pleistocene of South America and western Europe. A distinct subspecies of sabre-tooth cat *(Smilodon californicus brevipes* Merriam and Stock) also occurs in small numbers in the Rancho La Brea asphalt. It is distinguished from the more common type by the bones of its feet which are noticeably shortened.

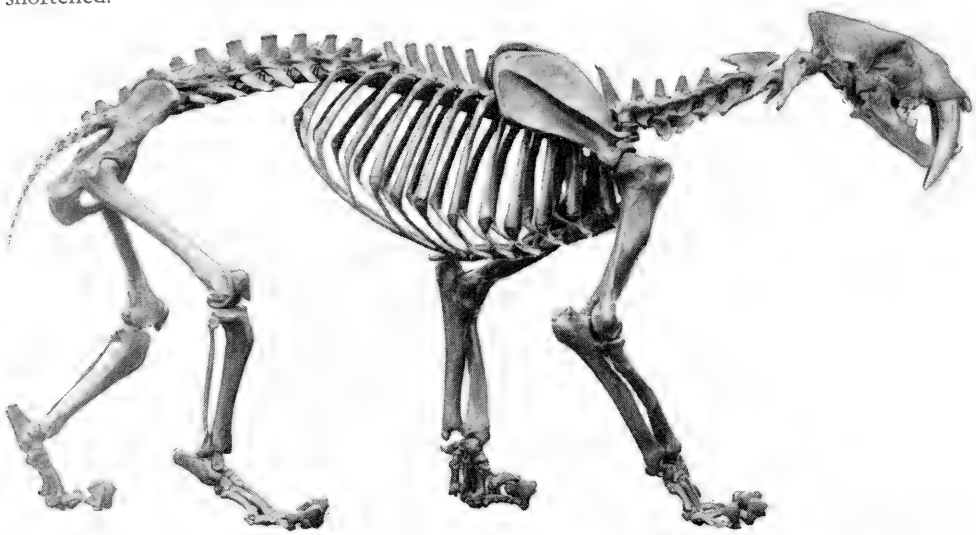

FIG. 18. Skeleton of the sabre tooth cat *(Smilodon californicus* Bovard). Los Angeles County Museum collection; Rancho La Brea Pleistocene.

For the group of true cats, represented today by the African lion, Indian and Asiatic tiger, African leopard, South American jaguar, and all other types of cats, the asphalt deposits reveal a noteworthy record. Undoubtedly the most remarkable member of this group is the great American lion-like cat *(Panthera atrox* (Leidy)), male individuals of which were nearly one-fourth larger than any of the large living cats of Eurasia. While it has become customary to speak of this feline as a lion, the species has also been called a gigantic jaguar. Unfortunately, nothing is yet known regarding the pelage and external coloration of this animal. While differing in size from the large living felines these creatures are no less unusual because of their close structural similarity to modern species. In certain features of the skull, *Panthera atrox* is more like the African lion than the Indian tiger. There is a noticeable size difference between the sexes. Skulls of females

from the brea approach in size the skulls of the larger male individuals of the South American jaguar. Without much question this great cat was the most formidable predatory mammal present in the Rancho La Brea assemblage. Only the short-faced bear exceeded it in size.

These powerful cats are by no means so well represented in the asphalt as their cousins, the sabre-tooth cats, although they overshadow in number types like the puma and lynx. Agile and strong of body and limb, fleet-footed, doubtless possessing to a superlative degree the grace of line, surety of step, and stealth of approach, so characteristic of the feline tribe, it is not difficult to conceive of *Panthera atrox* as the greatest hunter of the time. Stalking prey in the open, depending upon its great biting strength and speed in its attack on the larger herbivores, this magnificent creature was as characteristic of the North American continent during the Pleistocene as the lion is of the African veldt at the present time.

A type specifically identical with the Rancho La Brea form was described many years ago from the Pleistocene of Natchez, Mississippi, and this species has been recognized as far south as the Valley of Mexico and as far north as Alaska. During the glacial period large cats closely related to the North American species were widespread over the Eurasiatic area. While the sabre-tooth cats became extinct the world over, the group to which the great lion-like cat belongs still exists in the Old World and in South and Central America as well as southern North America.

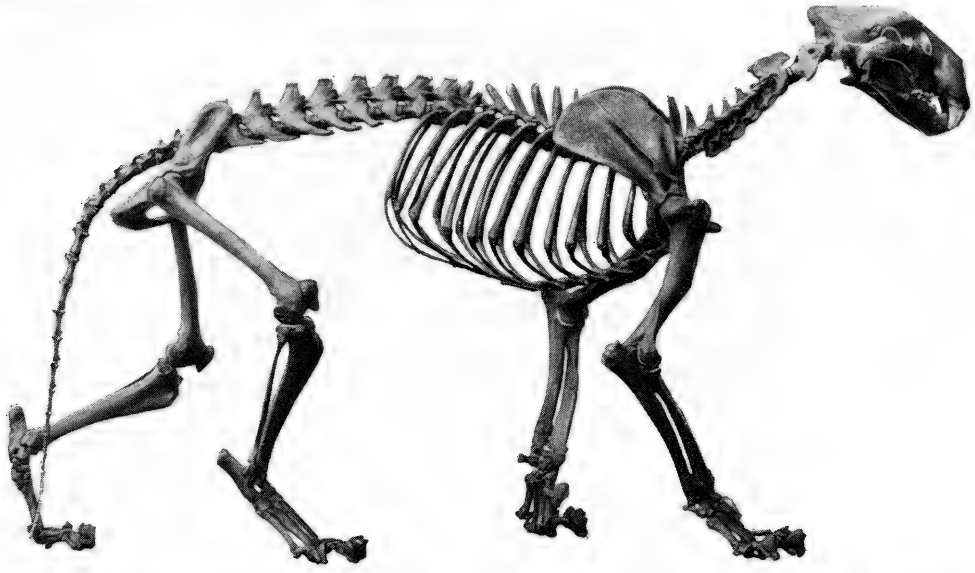

FIG. 19. Skeleton of the great cat *(Panthera atrox* (Leidy)). Los Angeles County Museum collection; Rancho La Brea Pleistocene.

In contract to the sabre-tooth cat and *Panthera atrox,* the puma and lynx occurring at Rancho La Brea are closely allied to types still living in western North America. The living species of puma *(Felis concolor* Linnaeus) is included in the collection. Of the two extinct species present, *Felis bituminosa* Merriam and Stock resembles *F. concolor* much more closely than does *Felis daggetti* Merriam. The latter is structurally similar to but

slightly larger than the western mountain lion. The lynx or bob-cat *(Lynx rufa fischeri* Merriam) resembles the species now found in California, but differs in characters of the cheek-teeth from the living subspecies.

RODENTIA (Gnawers)

Although remains of rodents are but sparsely represented in the Los Angeles County Museum collection, these forms are known by a number of skulls and many parts of skeletons in the collection of the University of California. The principal contributions to our knowledge of these forms have been made by Louise Kellogg (1912), Dice (1925), and by Wilson (1933).

The surface activities of rodents during the Pleistocene were probably instrumental in bringing about a record of the group at Rancho La Brea. The relatively minor outpours of tar which occur today at this locality on occasion catch these small mammals (see figure 3). Furthermore, the occurrence of particular kinds of rodents doubtless accounts also for the presence of certain species of birds and small carnivorous mammals known to feed on living representatives of these forms.

The entire rodent assemblage, including not less than nine species, bears a close similarity to types living in the Los Angeles region at the present time. The gopher *(Thomomys bottae occipitalis* Dice) is by far the most abundant rodent in the fossil collections from Rancho La Brea. The pocket-mouse *(Perognathus californicus* C. H. Merriam) and the kangaroo rat *(Dipodomys agilis* Gambel) are relatively abundant; the white-footed mouse *(Peromyscus imperfectus* Dice), meadow-mice *(Microtus californicus* (Peale) and *M. c. neglectus* L. Kellogg), and ground-squirrel *(Otospermophilus grammurus* (Say)) are less abundant; and the grasshopper-mouse *(Onychomys torridus ramona* Rhoades), harvest-mouse *(Reithrodontomys megalotis longicaudus* Baird), and wood-rat *(Neotoma,* sp. indet.) are rare.

It is interesting to note that many of the rodents are referred to living species and even to existing subspecies. In other words, while profound changes have occurred in the mammalian life of the Los Angeles area since the time of accumulation of the asphalt deposits, as indicated by the disappearance of many of the larger types, the rodents apparently have remained remarkably stable, not only with reference to the constituent members of the group as a whole but also with regard to the structural characters of particular forms.

LAGOMORPHA (Rabbits, Hares)

According to Dice (1925) at least three distinct types of lagomorphs are known from Rancho La Brea. These have been identified as the California jack-rabbit *(Lepus californicus orthognathus* Dice), the brush-rabbit *(Sylvilagus bachmani cinerascens* (Allen)), and the cottontail *(Sylvilagus audubonii pix* Dice). Both the jack-rabbit and the brush-rabbit are represented by only a few bones, but the cottontail is relatively abundant in the asphalt.

Here again close similarity has been recognized between the fossil forms and types now existing in the Los Angeles region, although the jack-rabbit and cottontail from Rancho La Brea are regarded as subspecifically distinct from their living representatives.

PERISSODACTYLA

Equidae (Horses)

The presence of herds of horses in the vicinity of the asphalt deposits during the period of accumulation is clearly testified to by the numerous remains of these mammals found at Rancho La Brea. While many individuals are recorded in the collections, all of them belong to a single species, the extinct western horse *(Equus occidentalis* Leidy). In

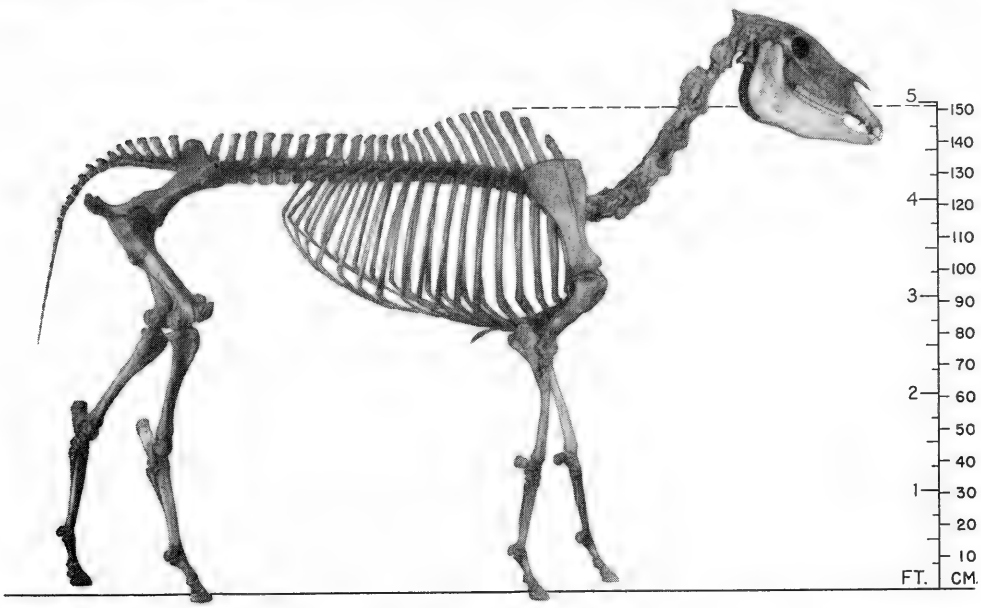

FIG. 20. Skeleton of western horse *(Equus occidentalis* Leidy). Los Angeles County Museum collection; Rancho La Brea Pleistocene.

stage of evolution and in general body structure this type resembles the modern horse, although differing from it in a number of specific details. Standing on the average about 14½ hands (4 feet, 10 inches) at the withers, this animal was of the height of a modern Arab horse. It was, however, of considerably heavier build.

In the fossil form the skull is somewhat domed in the region of the forehead and the sutures separating the individual bones of the skull in this area give a slightly different pattern from that seen in living species. In these two characters the Rancho La Brea horse exhibits some resemblance to the asses. Another noticeable difference between *Equus occidentalis* and *Equus caballus,* as the modern species is called, is presented in the front end of the lower jaw between the cheek-teeth and the cropping teeth. In this region the jaw is deeper in the fossil form. The dentition of the Rancho La Brea animal is not fundamentally different from that in modern species, but individual grinding teeth have a simpler enamel pattern. As a matter of fact, among the species of fossil horses described from the Pleistocene of North America, *Equus occidentalis* has one of the least complicated patterns developed by the enamel on the wearing surface of the tooth-crown.

These horses, like their living relatives, were one-toed animals. Limb and body are supported wholly by the enlarged third toe, while slender splintlike bones represent the elements which during an earlier history of the horse group were more fully developed

and carried the second and fourth toes. The hoofs in the Rancho La Brea species are distinctly smaller and more slender than in the larger types of existing horses. In this respect again, a greater resemblance is seen to exist with the asses and zebras.

The species, *Equus occidentalis,* has been known heretofore by isolated teeth and fragmentary skull material collected in Pleistocene deposits in Tuolumne County and in the Buena Vista Lake region of Kern County. Following identification of this form on the basis of the complete remains at Rancho La Brea, *Equus occidentalis* has been recorded from several additional Pleistocene localities in California. It is now known by many specimens that have been recovered from the asphalt deposits of McKittrick.

Horses were among the more common types of hoofed mammals on the North American continent during Pleistocene time and several distinct species have been described from fossil remains. The abundance and widespread distribution of horses in North America make the apparent disappearance of the group in this region prior to the advent of the white man an added and an unusual feature of their long and eventful career.

Tapiridae (Tapirs)

Although remains of this interesting group have not been recognized in the Los Angeles County Museum collection from Rancho La Brea, evidence indicating the presence of a tapir *(Tapirus,* ? sp.) in the asphalt is seemingly furnished by at least two phalanges in the collection of the University of California. Slight as this evidence may seem to be, the elements in question resemble the corresponding bones of the living tapir more closely than they do those of any Pleistocene mammal known from this locality.

The rare occurrence of tapirs in the asphalt record doubtless results from the fact that the environment in and about the tar traps was not particularly favorable to the group. Their sparse representation may indicate moreover that they were nowhere very abundant. Tapir remains are, as a matter of fact, of infrequent occurrence in California. Late Tertiary or Pleistocene records of these forms have been found in the auriferous gravels of the Sierra Nevada, in Santa Barbara County, in the Bautista badlands of Riverside County, at San Diego, and in the Palos Verdes beds at San Pedro, California.

ARTIODACTYLA

Tayassuidae (Peccaries)

The infrequent record of peccaries in the Pleistocene mammalian assemblage of California leaves much to be desired in our present knowledge of the extinct types. The most complete material thus far known from the state has been collected at Rancho La Brea and represents a fragmentary skull and several limb elements. These specimens indicate a form *(Platygonus,* sp.) which ranged widely over the United States and probably Mexico in Pleistocene time. Species closely related to the Rancho La Brea type have been described, for example, from fissure deposits in the lead region of Illinois, alluvial accumulations in northern Kansas, and from a number of additional localities in the east and middle west. In California the genus *Platygonus* has been recorded from the asphalt deposits of McKittrick in Kern County and doubtfully from the Pleistocene of Potter Creek Cave, Shasta County.

Peccaries are hog-like creatures representing the New World division of the pig-peccary group. Existing members of the family range from the region of northern Texas

to Patagonia. The characters of the skull and teeth are in general like those in swine, although differing from them in a number of important details. The skull specimen from Rancho La Brea exhibits the typical features found in *Platygonus.* Two incisor teeth are present on each side of the upper jaw, followed behind by a short, triangular-shaped canine tooth. The cheek-teeth have relatively low crowns on which a series of tubercles or cusps are developed. In the molars these cusps pair off to form two transverse crests which are, however, not so high as in modern peccaries.

Judging from the sparse record of the Pleistocene types in California and particularly at Rancho La Brea, one may conclude that peccaries favored more wooded regions and were not present in large numbers in the area immediately adjacent to the asphalt traps.

Camelidae (Camels)

Strikingly foreign as the camels appear to the North American mammalian life of today, this group of animals was well represented over the northern continental area of the New World during the Age of Mammals. Apparently only in late geologic time have they disappeared entirely from this region, the group as a whole being now represented by the bactrian camel of Asia, the dromedary of northern Africa, and the llamas of South America.

Several distinct types of camels are known from the Pleistocene of North America and some of these were presumably broadly distributed, ranging northward beyond the arctic circle. Remains of these creatures have been found at a number of localities in the United States from Washington to Florida.

The camels of Rancho La Brea all belong to a single species *(Camelops hesternus* (Leidy)). These were undoubtedly striking animals as they appeared in the region about the tar pools. The fossil materials furnish practically all the important structures of the skull and skeleton, the species being better known than any other camel type described from the Pleistocene. Two fine skeletons have been prepared and mounted from specimens collected by the Los Angeles County Museum (see figure 21).

The mounted specimens of *Camelops hesternus* show the unusual characteristics of these fossil forms. The skeleton has a height of more than 7 feet as measured from the highest point of the back, or more than 8 feet measured from the top of the skull. While the size of the body was somewhat like that in the bactrian camel, the fossil species has much longer legs. Whether or not the Rancho La Brea species possessed a hump or humps, as do the Old World representatives of the camel family, cannot be satisfactorily determined, for these structures leave no impress on the spines of the vertebrae. The llamas are without humps. While the camels native to the desert region of the Old World are adjusted structurally to a rigorous climate, the more favorable environment of the Rancho La Brea hinterland during the Pleistocene probably did not necessitate those special adaptations suited to an existence under arid conditions.

Although the skull of *Camelops hesternus* agrees more in size with that of the bactrian camel than with that of the South American llama, it resembles more closely the latter in certain structural characters. However, there remain other features in which the Pleistocene type differs from the camelids now living in both the Old and the New World.

Camel remains are by no means of infrequent occurrence in Pleistocene deposits of California, materials having been found in at least 15 counties of the state. Probably

several distinct types are represented. The species *Camelops hesternus* was first described in 1873 from beds in Livermore Valley, Alameda County. Skull remains of a camel identical with the Rancho La Brea form have been described by Romer (1925) from a cave near Fillmore, Utah. This specimen is remarkable because of its comparatively fresh

FIG. 21. Skeleton of large camel *(Camelops hesternus* (Leidy)). Los Angeles County Museum collection; Rancho La Brea Pleistocene.

state of preservation, for some of the dried muscle tissue is still attached to a part of the skull. Discovery of this interesting material, as well as of jaw and skeletal specimens of another extinct camel similarly preserved in Gypsum Cave, southern Nevada, has led to the belief held by some investigators that native camels continued to exist in North America during late geological time and perhaps into the Recent.

Cervidae (Deer)

Although the deer are now the most abundant of the larger game animals of California, they occur but rarely in the Rancho La Brea Pleistocene assemblage. Judging from the rather scanty material available, the Pleistocene deer *(Odocoileus,* sp.) are apparently related to the California mule deer *(O. hemionus),* although establishment of definite relationships of these forms must await a more critical examination of the fossil specimens.

The rarity of deer in the asphalt record may indicate an infrequent occurrence of the group during this stage of the Pleistocene, or the presence of environmental conditions

which were not particularly favorable to these types. Remains of deer have been recorded from a number of Pleistocene localities in California.

Antilocapridae (Antelopes)

This distinctly American family is represented today by a single form, the pronghorn (*Antilocapra americana* (Ord)), now largely restricted in its range to certain areas in the western part of the United States and northern Mexico. Prior to the advent of the white man, however, its distribution extended over a much larger area. Occurring also in California during the Recent period, its range in this region has likewise become much more restricted, and only a few herds are left. Fossil remains of species identical with or closely related to the pronghorn have been found in Pleistocene deposits at several localities in California. At Rancho La Brea *Antilocapra* cf. *americana* is represented by only a few specimens, one of which is a horn-core differing in some respects from that of the living antilocaprid.

Much more abundant in the asphalt, however, is a diminutive antelope (*Breameryx minor* (Taylor)) which clearly belongs to the antilocaprid family, although exhibiting some interesting differences from the American antelope of today. This animal (figure 22) was less than 2 feet tall at the shoulders or approximately 27 inches as measured to the

FIG. 22. Skeleton of small antelope (*Breameryx minor* (Taylor)). Los Angeles County Museum collection; Rancho La Brea Pleistocene. After Furlong.

top of the head. The Pleistocene type possessed long-crowned grinding teeth, suggestive of grazing habits similar to those of the pronghorn. While no complete skull has been found at Rancho La Brea, sufficient material is available to permit determination of the character of the bony horn-core. This interesting structure, growing on each side from the top of the skull above the rim of the eye-socket, consists of two distinct prongs arising from a common base. The hinder of the two prongs is the longer and has a round cross-section, while the front prong is decidedly shorter and has a triangular cross-section. Although the sword-like horn-core of the modern pronghorn antelope shows no separation into two parts, the contour and shape of this structure are rather strongly indicative of a kinship between the modern type and *Breameryx.* Moreover, in the fossil form the cleft separating the two prongs suggests the presence of a forked sheath covering the horn-core. The existing pronghorn is the only known case among living mammals in which a simple horn-core carries a forked sheath.

A number of resemblances are to be noted in a comparison of the skeletons of *Breameryx* and *Antilocapra.* Like the latter the fossil form possessed long, light limbs, in which respect it can be separated from most of the true antelopes of the Old World. The long-crowned teeth serve to distinguish it from the light-limbed African gazelles.

It is difficult to visualize the presence of delicate creatures like *Breameryx* in a region in which so many formidable carnivorous animals also existed. Perhaps these antelopes normally sought shelter in the copses of trees and shrubs in the vicinity of the tar pools, coming into the open only at certain times of the day or night to feed.

Specimens assigned to the genus *Breameryx* have been recognized, in spite of the rather fragile nature of the remains, in Pleistocene deposits of New Mexico and of the Valley of Mexico. Additional records of the presence of this group of animals in the California region are known from Pleistocene beach accumulations at San Pedro, from the asphalt deposits at McKittrick, Kern County, and doubtfully from the Bautista Creek badlands of Riverside County.

Bovidae (Bison)

Judging from their record in the asphalt the bison or buffalo, represented by more than 100 individuals, were even more numerous than the horses in the vicinity of Rancho La Brea during the Pleistocene. The total number of these animals exceeds that of all other even-toed hoofed mammals (camels, peccaries, antelopes, and deer) found at this locality. It should be clearly borne in mind, however, that factors other than abundance of individuals may have been instrumental in bringing about the large representation of the bovid group in the tar. The extinct bison, with habits similar to those of the modern species, may easily have fallen victim to the deceptive appearances of the tar pools.

The similarity of the fossil forms to the living species in fundamental characters offers little difficulty in visualizing these creatures in the flesh as they roamed over the plains and rolling country of the Los Angeles area during the Pleistocene. These ancient bison *(Bison antiquus* Leidy) were larger than the modern North American buffalo *(Bison bison* Linnaeus), the skeleton as mounted (figure 23) having a height of more than 7 feet, measured from the highest point of the back. Some individuals were probably distinctly taller. That the fossil bison like their living relatives, possessed a hump is indicated by the great development of the spines of the vertebrae in the forward region of the back. Vertebrae are available in the collection with spines measuring from 26 to 27 inches in length.

Structurally *Bison antiquus* resembles *Bison bison,* but differs from it in certain specific details in addition to size. In the skull, for example, the horn-cores project outward at right angles to the median fore and aft axis of the head, whereas in the living species they are directed somewhat backward as well as outward. The largest skull in the Museum collection has a span of 32 inches as measured between the tips of the horn-cores. It is

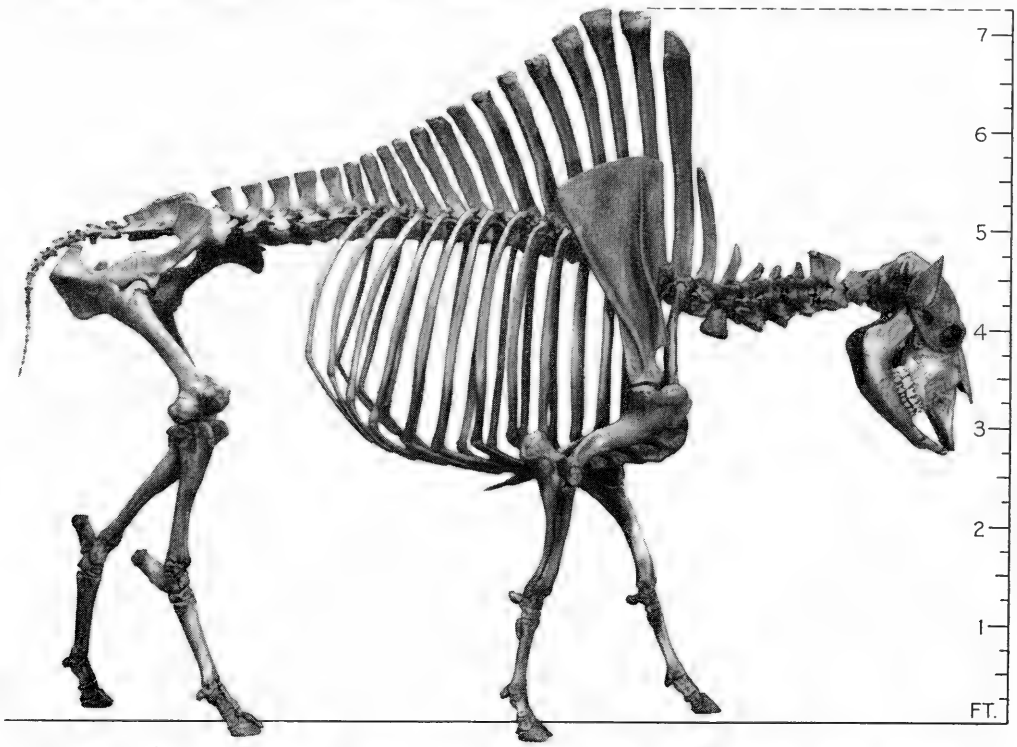

FIG. 23. Skeleton of ancient bison *(Bison antiquus* Leidy). Los Angeles County Museum collection; Rancho La Brea Pleistocene.

not improbable that some individuals possessed a width across the skull of more than a yard as measured from the outer sides of the horny sheaths which covered the horn-cores. Skulls of males and females are apparently to be distinguished by the size of the individual horn-cores.

Remains of fossil bison of the species *Bison antiquus* were recorded many years ago from deposits in Livermore Valley, Alameda County, California. This type is represented also in the asphalt deposits of McKittrick. During its existence on the North American continent the species was widely distributed, for *Bison antiquus* was first described from the Pleistocene of Kentucky. A rather frequent record of bison has been found in the Pleistocene of California, and remains of these types, when not too fragmentary, seemingly indicate the presence of several species in this region. The largest of these is known by a complete skull from an ancient lake bed in Shasta County. In this specimen the spread of the horns measured more than six and a half feet from tip to tip.

PROBOSCIDEA

The American mastodon is known to have ranged during Pleistocene time from Alaska to Florida and from New England to southern California. The emperor and

Columbian mammoths, on the other hand, were limited in their distribution to the southern and southwestern parts of the United States and the Valley of Mexico. Remains of Pleistocene mastodons and elephants have been found at a number of localities in California, and it is apparent that several species of mammoths were present in this region during the Glacial Period.

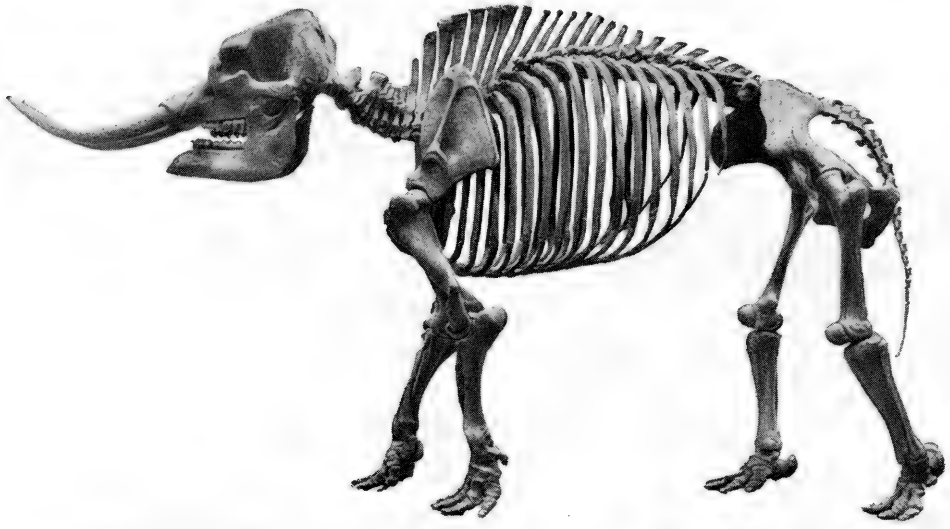

FIG. 24. Skeleton of American mastodon *(Mastodon americanus* (Kerr)). Los Angeles County Museum collection; Rancho La Brea Pleistocene.

Elephant and mastodon remains are by no means of frequent occurrence in the Rancho La Brea collections. In reaching a full understanding of these types an added difficulty is experienced in the comparatively imperfect preservation of a number of the larger skeletal parts. This is particularly true for the elephants whose remains were collected by the Los Angeles County Museum in a single excavation (Pit 9). Here the presence of clay and sand saturated with water hastened somewhat the disintegration of the skulls and of the long bones of the limbs. On the other hand, remains of the mastodon encountered at Rancho La Brea are usually in a better state of preservation.

Mastodontidae (Mastodons)

The contemporaneity of the mastodon and elephant is clearly indicated in the brea occurrence. The former type, determined as the American mastodon *(Mastodon americanus* (Kerr)), was of smaller size than the elephant and possessed a number of primitive features, but exhibited nevertheless many of the outward charactersitics of the elephant tribe. A mounted specimen of this type from the asphalt is shown in figure 24. This skeleton measures 6 feet 3 inches in height to the top of the shoulder blade. The tusks of the mastodon, made of dentine or ivory, are of smaller size than those of the Pleistocene elephants and their curvature is not so marked as in the latter. A greater number of grinding teeth are present in the jaws and the individual tooth differs noticeably in its structure from that of the elephant. These teeth are comparatively low-crowned, each crown forming a series of crests and V-shaped valleys which extend transversely. There is no cement on the wearing surface of the grinders in the American mastodon.

Elephantidae (Elephants)

The elephants or mammoths of the asphalt were distinctly larger than the mastodon, and exceeded in size their living relatives. Some of these animals had a height of more than 13 feet as measured at the shoulders. The skeleton mounted in the exhibition hall of

FIG. 25. Skeleton of emperor mammoth *(Archidiskodon imperator* (Leidy)). Los Angeles County Museum collection; Rancho La Brea Pleistocene.

the Museum, figure 25, measures in height 10 feet 8½ inches to the top of the shoulder blade, and 11 feet 7 inches to the top of the skull. Apparently both the emperor mammoth *(Archidiskodon imperator* (Leidy)) and the Columbian elephant *(Parelephas columbi* (Falconer)) occur at this locality. The tusks were huge structures and were present only in the upper jaw. The grinding battery in adult animals consists of a single large tooth situated on each side of the upper and lower jaw. As in modern elephants the crown of each tooth is made up of a series of compressed enamel plates enclosing dentine and virtually embedded in a heavy deposit of cement. The long-crowned teeth exhibit great wearing qualities and undoubtedly contributed to the longevity of these animals. The large skull furnished an expanse of external surface for attachment of muscles and tendons necessary in the manipulation of the trunk and in the support of the tusks. The heavy body was supported by the pillar-like limbs.

XENARTHRA (Ground Sloths)

The ground sloths are among the most unusual types of herbivores occurring in the asphalt. Belonging to the edentates, an important and rather primitive group of mammals, these forms are definitely known to have emigrated from the South American continent to North America. Forerunners and close relatives of some of the Rancho La Brea types had already reached the northern continent during the Pliocene, the epoch immediately preceding the Ice Age. Living representatives of the Xenarthra, which are found today in South and Central America, are the armadillos, anteaters, and tree sloths. Armadillos occur also in North America, but their geographic range is largely restricted to certain parts of Texas and Oklahoma.

Among existing edentates the nearest relative of the extinct ground sloth is the tree sloth. This form, as its name implies, is a tree-dweller and is characterized by sluggish movements. It lives in the dense forests of Central and northern South America. In contrast to other arboreal mammals the tree sloth has the peculiar habit of moving about with its body suspended from the branches of trees, using for support the large claws on its hands and feet. Of relatively small size, it feeds on the foliage of the trees, and when forced to the ground moves about with difficulty. The tree sloth possesses a shaggy coat of hair and in some forms this has a protective color, due to the presence of a green alga which lives normally in the flutings or grooves of the individual hair shafts.

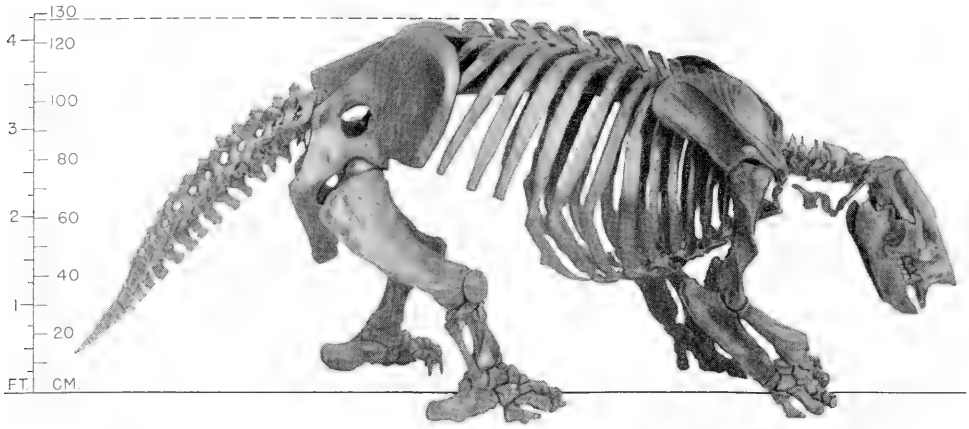

FIG. 26. Skeleton of mylodont ground sloth *(Paramylodon harlani* (Owen)). Los Angeles County Museum collection; Rancho La Brea Pleistocene. After Stock.

The extinct edentates of the western hemisphere include not only the ground sloths, but types characterized by a heavy bony armor which protects the head and encases the body and tail. The glyptodonts, as they are called, are like the armadillos in possessing this protective covering of bony dermal plates or scutes. These animals are not known in the fossil record of California.

Some of the edentates, notably the anteaters, are toothless. When a dentition is present, as in some forms, the teeth lack the hard outer substance, namely the enamel, which is an important constituent of the tooth crown in higher mammals. The ground sloths had teeth of this type, in which the principal substance forming the crown was dentine of varying hardness. As the teeth were worn down they continued to grow from within the sockets, very much as do the gnawing teeth of rodents.

Mylodontidae (Grazing Ground Sloths)

Three distinct species of ground sloths are known from the Rancho La Brea deposits. Of these forms *Paramylodon harlani* (Owen) was the commonest type. This creature, represented in the collections of the Los Angeles County Museum by very complete skull and skeletal materials, was much smaller than the mastodon, but, like that species, possessed considerable bulk and weight. Somewhat blunt-nosed and with lobate grinding teeth *Paramylodon* was probably a grazing mammal frequenting the open stretches of flat or rolling country in the vicinity of the asphalt beds. Presumably its natural enemies were the sabre-tooth cat, the great lion-like cat, and the packs of dire wolves. The skeleton

of this ground sloth is massively constructed and the strongly built chest and powerful front limbs suggest great crushing strength. These characters and the stout claws of the hand were undoubtedly of great service to the animal in combating the attacks of predatory mammals (figure 26).

An additional protection, particularly against neck and body attacks, was furnished by the nodules of bone, or dermal ossicles as they are called, embedded in the deeper layers of the skin. These bony elements have the same origin as the scutes in the armadillos and glyptodonts. While the skin or hide of *Paramylodon* is not preserved in the tar, the occurrence of these nodules is definitely indicated by the fact that they were found frequently in great abundance lying in the asphalt immediately adjacent to the skeletal remains of these animals. Moreover, our knowledge of the structure of the skin in the mylodont ground sloths has been enriched by a discovery made many years ago of remains of creatures closely related to the Rancho La Brea forms in a cave deposit in southern Patagonia. Here occurred not only the skull and skeletal remains but patches of the hide, showing the presence of dermal ossicles in the deeper layers of the skin and the coarse shaggy hair on the outside. This discovery has had an important bearing on the interpretation of the characters of the Rancho La Brea mylodonts and on the restoration of these curious creatures.

The mylodont ground sloths enjoyed an extensive distribution over the American continent during the Pleistocene, their remains having been recorded, usually in association with those of plains-dwelling mammals, from the northern United States to Patagonia. In California *Paramylodon* is known to have ranged from the Klamath River region southward to the Los Angeles basin and a dozen or more localities within the state are now known where skull or skeletal materials have been found. It is now well established that the so-called "human tracks" preserved in the silts and sandstones exposed in the prison yard of the Nevada State Penitentiary at Carson City, Nevada, are the foot-prints of this kind of ground sloth.

A variety of this species *(Paramylodon harlani tenuiceps* (Stock)) is also recorded from Rancho La Brea.

Megatheriidae (Browsing Ground Sloths)

Next in abundance were the nothrotheres *(Nothrotherium shastense* Sinclair), also ground sloths, but creatures of smaller size and of somewhat different appearance and habits than *Paramylodon.* The specimen shown in figure 27 is unique not only because it is largely constructed of skeletal parts of a single individual, but likewise because the mounted skeleton represents the first of its kind to be attempted. At the time the materials were assembled for mounting, *Nothrotherium* appeared to be so little known as a member of the North American company of Pleistocene mammals as to suggest the retention of its individual skeletal parts in a state which would permit their future study and comparison. As a result, a plaster replica was made of each element and these rather than the originals were mounted. However, subsequent explorations at new localities, as for example at Aden Crater, New Mexico, and in the cave of San Josecito, Nuevo Leon, Mexico, have brought to light excellently preserved remains of this ground sloth.

The nothrotheres are characterized by a fewer number of teeth than *Paramylodon* (8 above and 6 below) and the individual tooth was not lobate as in the latter but of a rectangular outline. The chisel-like edges on the teeth indicate a cutting or chopping

rather than a grinding action in chewing food and suggest a browsing habit. The skull was somewhat tubular in front and the lower jaw has a spout-like forward end. Fundamentally the skeleton is like that in *Paramylodon,* although differing in a number of details. Rudimentary bony nodules were apparently absent in the skin. Perhaps the most remarkable feature is presented in the hind foot, which has undergone profound modification. Whereas in the plantigrade mammals the sole of the foot rests on the ground, in *Nothrotherium* the foot has been rotated from this position and the weight of the body rests on the outer side of the foot. As a result of this curious change the outer toes particularly have suffered considerable reduction. A similar modification occurs also in the hind foot of *Paramylodon,* but the change is in some respects not so striking as in the nothrotheres. Claws are present on both the feet and hands, as in the mylodonts.

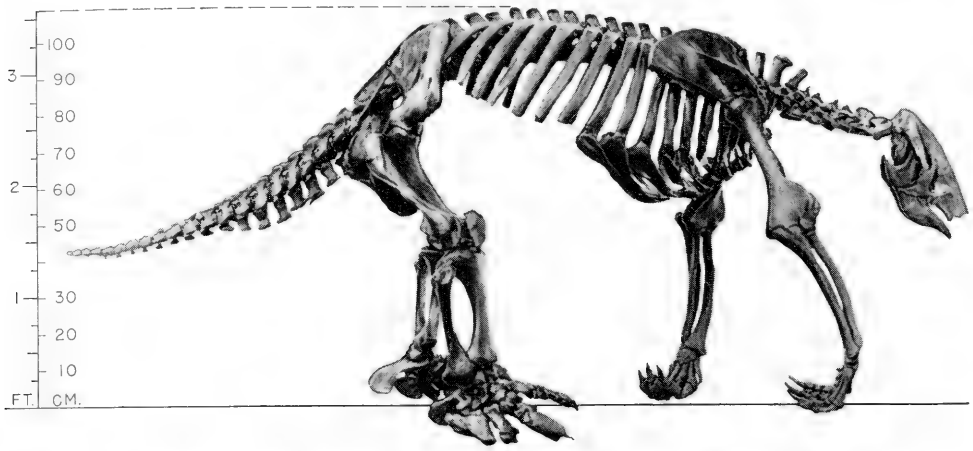

FIG. 27. Skeleton of small ground sloth *(Nothrotherium shastense* Sinclair). Los Angeles County Museum collection; Rancho La Brea Pleistocene. After Stock.

It is difficult to conceive of these mammals moving with any degree of rapidity over the surface of the ground. Rather is one inclined to conclude from their ungainly appearance, and from what one may be tempted to designate as malformation in some parts of their skeletal structure, that they were characterized by a slow and labored gait. Yet these characters were apparently in no wise a handicap in their distribution for the nothrotheres are found not only in Pleistocene strata of North America but in Brazilian cave deposits as well. These ground sloths were first described in California in cave accumulations in Shasta County. They have since been recognized at Hawver Cave in El Dorado County, California, and in Nevada, Arizona, Texas, New Mexico, and Mexico. The bones of *Nothrotherium* from Gypsum Cave, Nevada, are quite recent-looking with bits of dried integument and hair still associated with them. Whether these ground sloths lived in the region contemporaneously with Man is still an open question, but there is much evidence to indicate that they survived in the Southwest into early Recent time.

Studies of the plants in the dung of *Nothrotherium* from the dry caves in Nevada and Arizona indicate that this animal fed on yucca and other plants associated with this type. There is every reason to believe that the nothrotheres lived in a rather arid environment, like that found today in the Joshua tree forests of the Clark Mountains of Nevada. They do not appear to have been habitual residents of Rancho La Brea, but seemingly penetrated this region on occasion from adjacent areas.

A third type of ground sloth *(Megalonyx jeffersoni californicus* Stock) is more sparingly represented in the asphalt than *Nothrotherium.* This type is more closely related to the nothrotheres than to *Paramylodon,* but approximates more nearly the latter in size. *Megalonyx* possesses considerable historic interest, for large claws and other bones of this creature were first described in 1794 from a limestone cavern deposit in western Virginia by Thomas Jefferson. Since that time *Megalonyx* has been recognized in Pleistocene beds at a number of localities in the United States, often in association with forest-dwelling mammals. In California this ground sloth is known also from Pleistocene cave accumulations in Shasta County and in the Sierran region. In the late Pleistocene Palos Verdes formation of the San Pedro Hills occurs a closely related species *(Megalonyx milleri* Lyon) which resembles the Rancho La Brea form, but appears to be specifically distinct from it. No skulls have been found at Rancho La Brea which may be compared with this material, but a lower jaw and a number of scattered skeletal elements have been recovered.

Megalonyx is quite similar in structure to the nothrotheres. The teeth are shaped somewhat as in the smaller form, but there is a caniniform tooth at the front end of each tooth row in the upper and lower jaws which is absent in *Nothrotherium.* The skull of *Megalonyx,* as known from other localities, appears to terminate more bluntly in front than does that of the nothrotheres. Available remains of the skeleton indicate an animal heavier and more massively constructed than *Nothrotherium,* but with many of its peculiarities. *Megalonyx* apparently also lacked the bony nodules in the skin, but was probably covered by a heavy coat of coarse hair.

BIRD ASSEMBLAGE

The rarity of birds in the geologic record is an acknowledged fact and is due in large measure to the fragile nature of their remains and to the special conditions of rapid entombment that are frequently necessary for their preservation. There appears to be no particular reason for assuming that birds of flight were less numerous during later geologic time than at present. On occasion quite complete remains are encountered as fossils in sedimentary deposits. The occurrence of fragmentary specimens in formations representing several epochs of the Age of Mammals gives clear evidence of the existence of many kinds of birds, some differing widely from living species and others indistinguishable from modern types. Our knowledge of fossil birds, however, has not reached a point where similar forms have been identified at a large number of localities of the same geologic age. In other words, the geographic distribution of extinct species of birds is not so well defined as that of extinct mammals.

In the light of the known paleontological record of birds, the Pleistocene occurrence at Rancho La Brea grows considerably in significance. The birds of this deposit form a more varied and certainly no less interesting assemblage than the mammals. Approximately 126 different types have been recognized, and to this list probably others will be added as the study of the avian group progresses. The fossil bird assemblage is comprised of a number of species that cannot be distinguished specifically from their living relatives. Some are known that were formerly referred to living species, but on further study have come to be regarded as slightly but significantly different. As a matter of fact, they are now considered to be the direct ancestors of closely related living species. Still others, known principally from Rancho La Brea, but subsequently identified at other Pleistocene localities, are so greatly different from modern birds as to clearly represent extinct types. So abundant are the skeletal remains in the asphalt that they can be reassembled and

mounted skeletons prepared for individual kinds of birds. This is one of the many unique features of the collection on display at the Los Angeles County Museum.

The unusual conditions responsible for the remarkably complete record of the mammalian life of the region were no less favorable in bringing about a full representation of the birds. It is not surprising to find a relatively high mortality among these types, considering the effectiveness of the lure which attracted many of them to the asphalt traps. The ensuing danger of miring in the tar on chance contact of wings or feet with the sticky material was extremely great. Even the more powerful birds of flight obviously suffered a decided disadvantage once their principal means of escape were rendered useless. Further struggles merely caused them to sink deeper into the tar.

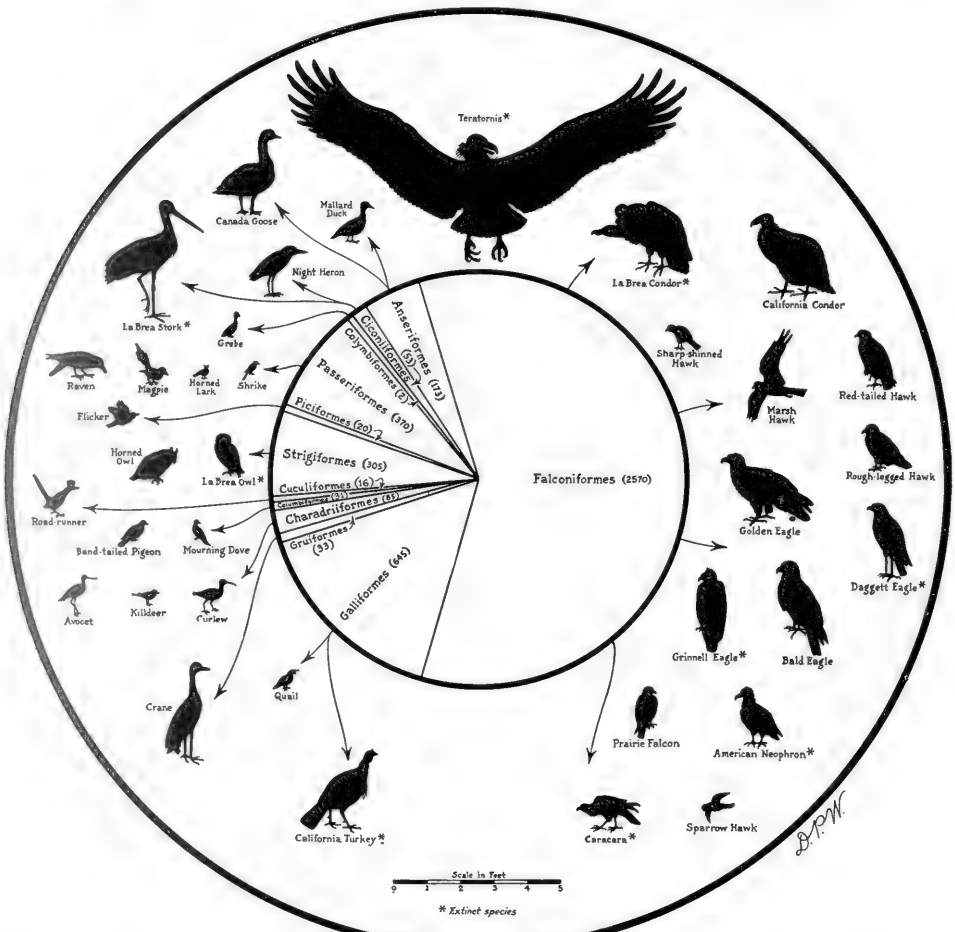

FIG. 28. Diagram illustrating relative number of individuals in the avian orders occurring in the Rancho La Brea Pleistocene fauna. Note: The California Condor from the asphalt is now considered an extinct species ancestral to the living bird, and this relationship probably also existed between the Pleistocene and Recent Golden Eagles. Data from Hildegarde Howard.

Varied doubtless were the causes responsible for the representation of birds. The record of specific kinds of birds in the fossil assemblage is considered to be an expression

of the relative frequency of occurrence of such forms in the region about Rancho La Brea. The presence of live bait furnished by mammals and other creatures trapped in the tar and of carcasses not yet wholly submerged undoubtedly served to attract from some distance away the predatory and scavenger types of birds. A large number of eagles and vultures soaring and circling in the sky above the pools probably was a common sight during the active period of the traps. Remains of raptors and of crows, ravens, and magpies are found in great numbers in the asphalt. Not only feeding habits but environmental conditions as well were presumably of considerable importance in bringing about a highly diversified avian population.

FIG. 29. Skeleton of asphalt stork *(Ciconia maltha* Miller). This mounted specimen measures 4 feet 5 inches in height. Los Angeles County Museum collection; Rancho La Brea Pleistocene. After Howard.

COLYMBIFORMES (Grebes)

Determination of the presence of grebes is based upon two specimens in the Los Angeles County Museum collection, representing two small forms *(Colymbus,* sp.), and the pied-billed grebe *(Podilymbus podiceps* (Linnaeus)). While grebes are known to occur elsewhere in Pleistocene deposits of western North America, notably at Fossil Lake in southern Oregon, their infrequent occurrence in the asphalt suggests an environment in which permanent lakes or ponds were absent. No doubt temporary bodies of water of varying size occupied the natural depressions at the Rancho La Brea locality, particularly during the wet seasons, and these might well have served to attract aquatic birds.

CICONIIFORMES (Stork-like Birds)

Although there is considerable range of type within this group as it occurs in the Pleistocene asphalt, most of the forms are represented by relatively few individuals. Only the stork is fairly abundant. The rarer species include the American egret *(Casmerodius albus* (Gmelin)), snowy egret *(Egretta thula* (Molina)?), a heron related perhaps to the little blue heron *(Florida caerulea* (Linnaeus)), the green heron *(Butorides virescens* (Linnaeus)), black-crowned night heron *(Nycticorax nycticorax* (Linnaeus)), white-faced glossy ibis *(Plegadis guarauna* (Linnaeus)), and probably the roseate spoonbill *(Ajaia ajaja* (Linnaeus)?), each possibly represented by not more than one individual. Slightly more frequent in occurrence are the

great blue heron (*Ardea herodias* Linnaeus) and the American bittern (*Botaurus lentiginosus* (Montagu)). All of these birds are apparently closely related to or identical with their living representatives.

The stork from the asphalt (*Ciconia maltha* Miller) differs from all modern species, but appears to be most closely related to *Ciconia ciconia* and *Euxenura galatea* (figure 29). All fossil stork remains from North America are now assigned (Miller, 1932; Howard, 1941) to one species, *C. maltha,* which is quite constant in all characteristics except size. The stork from the Pleistocene of Florida, tending to be slightly larger than the California fossil, may represent a separate subspecies, *C. m. weillsi.* The range in size of *C. maltha* includes both the Jabiru and the Maguari storks. The fossil stork has longer wings than either *Euxenura* or *Jabiru,* and is more slender in all respects than the latter. Regarding the occurrence of the form at Rancho La Brea, Dr. Miller (1925) remarks: "The fairly abundant remains of this stork in the asphalt deposits must not be interpreted as indication of a greater humidity in the region than is at present encountered there. Various writers upon the habits of storks in both Old and New Worlds speak of the plains-dwelling habit of the birds, especially during insect outbreak, such as the locust storms of Palestine and of Argentina." According to Dr. Miller, the *Ciconia maltha* may have been similar in appetite and appearance to the Maguari stork now living in the Argentine pampas.

ANSERIFORMES (Goose-like Birds)

The presence of water, forming surface pools at Rancho La Brea, is indicated also by the occurrence of ducks and geese. While these birds are recorded in greater number than the grebes, their total representation is still rather limited. In so far as determination can be made of the fossil material, most of the types are either identical with or closely related to living species. The assemblage includes the whistling swan (*Cygnus columbianus* (Ord)), Canada goose (*Branta canadensis* (Linnaeus)), white-fronted goose (*Anser albifrons* (Scopoli)), snow goose (*Chen hyperborea* (Pallas)), Ross goose (*Chen rossi* (Cassin)?), mallard duck (*Anas platyrhynchos* Linnaeus), gadwall (*Chaulelasmus streperus* (Linnaeus)), green-winged teal (*Nettion carolinense* (Gmelin)), an unidentified teal (*Querquedula,* sp.), the shoveller duck (*Spatula clypeata* (Linnaeus)), and two diving ducks, one similar to the canvas-back (*Nyroca valisineria* (Wilson)?) and another somewhat smaller form. The only extinct anserine thus far recorded from Rancho La Brea is the brea pigmy goose (*Anabernicula minuscula* (Wetmore)), which shows characters of both the ducks and the geese but is considerably smaller and more slender-legged than any living goose. The species has been recorded from the upper Pliocene of Arizona, from the McKittrick asphalt, and similar forms from Quaternary cave deposits in Nevada and New Mexico and from Fossil Lake, Oregon (Howard, 1946, pp. 171-173).

FALCONIFORMES (Falcon-like Birds)

Within this group of raptors perhaps the most striking type is an extinct condor-like vulture (*Teratornis merriami* Miller). This great bird (figure 30) was first described from Rancho La Brea, but it has since been recognized in the asphalt assemblages of Carpinteria

and McKittrick, California, and in the Pleistocene of Florida and Nuevo Leon, Mexico. Standing about 2½ feet high, *Teratornis* possessed a wing-spread of at least 12 feet and ranks among the largest known birds of flight. In life the bird weighed possibly 50 pounds. Its skull and skeleton exhibited a curious combination of eagle- and vulture-like characters. The top of the cranium is flattened and the beak is noticeably compressed transversely, giving the head an aquiline appearance. In the structure of the skeleton, however, resemblances are seen pointing unmistakably to a kinship with the vultures. The feet are quite condor-like, but seem surprisingly small and weak when compared with the great size of the body, wings, and head.

Several additional unique features may be mentioned with regard to the skull. The hooked beak in life was probably covered by a stout horny sheath possessing considerable strength in biting and in the tearing of flesh. The articulation of the lower jaw permitted apparently a considerable gape to the mouth. The external nasal openings through the beak are of enormous size and are indicative perhaps of an especially acute sense of smell on the part of this bird. Lastly, the brain-case is relatively small, suggesting a size of brain in keeping with the presumed rapacious habits of *Teratornis.*

Another extinct teratorn *(Cathartornis gracilis* Miller) has been recorded from the asphalt. This bird is represented only by two tarsometatarsi which resemble those of *Teratornis* but are more slender than any bones assigned to that species.

A vulture *(Gymnogyps amplus* Miller) resembles closely in structure of skull and skeletal elements (figure 31) but is slightly larger than, the existing California condor *(Gymnogyps californianus* (Shaw)) and is represented by many individuals in the asphalt. Judging from the habits of this powerful bird of prey its presence in large numbers at Rancho La Brea might well be expected. Further records of the condor in the Pleistocene have been found at Carpinteria and McKittrick (where the bird is extremely rare), in Pinellas County, Florida, and in southern Nuevo Leon, Mexico. Remains also occur in sub-Recent cave deposits in Nevada, New Mexico, and Texas. *Gymnogyps amplus,* the species occurring at Rancho La Brea, was first described from the Pleistocene caves of Shasta County, California. Within the Recent period the California condor is known to have ranged from the Columbia River southward to Lower California, but due in part to the persistence with which it has been persecuted by Man, the species has become much more limited in its geographic distribution and the individuals greatly reduced in numbers.

The Rancho La Brea collection also includes another vulture *(Breagyps clarki* (Miller)), which closely parallels the living condors in size but has a distinctive long beak. This species is represented in the asphalt by several individuals.

At least four additional kinds of vulturine birds are known from Rancho La Brea. It is interesting to note that within the group two carrion-feeders *(Neophrontops americanus* Miller and *Neogyps errans* Miller) are related to the Old World vultures, whose representatives are not now living in America, and the third, the western black vulture *(Coragyps occidentalis* (Miller)), is closely allied to the living black vulture of the middle west and southern states. All these species are also members of the Pleistocene avifauna recovered from San Josecito Cave, Nuevo Leon, Mexico. Only the turkey vulture *(Cathartes aura* (Linnaeus)) of the Rancho La Brea Pleistocene is still found living in the California region. Curiously enough this species is represented in the asphalt by relatively few individuals. Since Pleistocene time it has increased greatly in abundance while the California condor has declined in numbers almost to the point of extinction.

Of the smaller birds of prey many distinct kinds are found. Kites are known by a single specimen identical with the Recent bird *(Elanus leucurus* (Vieillot)). Among the hawks are numbered several species, including the marsh hawk *(Circus hudsonius* (Linnaeus)), goshawk *(Astur atricapillus* (Wilson)), sharp-shinned hawk *(Accipiter striatus velox* (Wilson)), Cooper's hawk *(Accipiter cooperii* (Bonaparte)), red-tailed hawk *(Buteo jamaicensis* (Gmelin)?), Swainson's hawk *(Buteo swainsoni* Bonaparte), rough-

FIG. 30. Skeleton of the great condor-like vulture *(Teratornis merriami* Miller). The wings of this teratorn, when unfolded in life, are estimated to have measured 12 feet from tip to tip. Los Angeles County Museum collection; Rancho La Brea Pleistocene.

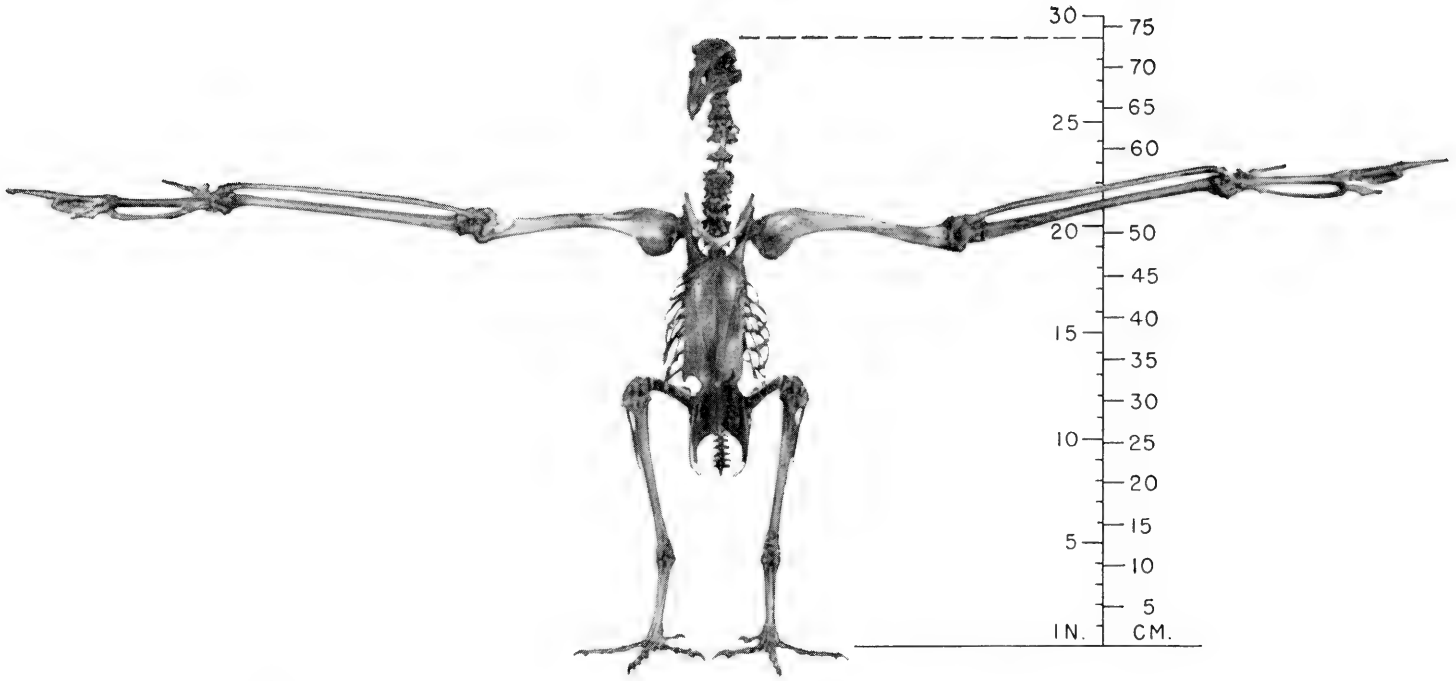

FIG. 31. Skeleton of the extinct condor *(Gymnogyps amplus* Miller). Los Angeles County Museum collection, Rancho La Brea Pleistocene.

legged hawk *(Buteo lagopus* (Brunnich)), and ferruginous rough-leg *(Buteo regalis* (Gray)). All of the fossil remains of hawks which are now identified have been referred to these living forms. In addition, there are a number of bones of buteonid hawks that have not yet been assigned to species.

The eagle population also exhibits considerable diversity. In addition to the two species now living in North America, there are several extinct forms whose nearest relatives are found today in South America. The golden eagle *(Aquila chrysaetos* (Linnaeus)) has persisted from Pleistocene time into the Recent. This species occurs more abundantly at Rancho La Brea than any other bird, a census indicating in excess of 800 individuals in the Los Angeles County Museum collection. Less numerous are the remains of the bald eagle *(Haliaeetus leucocephalus* (Linnaeus)), whose characters are more variable than those of the modern races of this bird.

FIG. 32. Skeleton of La Brea caracara *(Polyborus prelutosus* Howard). Los Angeles County Museum collection; Rancho La Brea Pleistocene. After Howard.

In contrast to these forms, the morphnine eagles, with one species *(Morphnus woodwardi* Miller) in the Pleistocene avifauna, are now confined to Central and South America. Likewise the crested eagles of the southern hemisphere have a related form *(Spizaetus grinnelli* (Miller)) at Rancho La Brea. Yet another type from the asphalt is the slender-limbed *Hypomorphnus fragilis* (Miller), which is related to a species now found in the southern part of the United States. Perhaps the most interesting of all is a long-legged eagle *(Wetmoregyps daggetti* (Miller)). Resembling superficially the living secretary bird of South Africa and the Central and South American *Hypomorphnus* in certain structural adaptations, *Wetmoregyps* possessed legs almost as long as those of the great

blue heron, suggesting ground habits considerably different from those of typical members of the eagle tribe. The fact that this species is more abundant in the small avifauna from Carpinteria than it is at Rancho La Brea suggests, however, that *Wetmoregyps* was a forest dweller rather than an inhabitant of open plains. It is interesting to note that this species does not occur in the McKittrick asphalt, but has recently been found in the Pleistocene deposits of San Josecito Cave, Mexico.

Remains of a small caracara, also a carrion-feeder, were early recorded from Rancho La Brea, but its identity with the living species has for some time been considered rather doubtful. A detailed study of the material (figure 32) leads to the conclusion that a distinct species is represented which shows closest relationship to the Guadalupe Island bird, recently extinct. With the description of a new subspecies of this caracara from the Pleistocene of San Josecito Cave, the name of the California bird becomes *Polyborus prelutosus prelutosus* Howard.

The falcons occurring in the Rancho La Brea avifauna include the prairie falcon (*Falco mexicanus* Schlegel), duck hawk (*Falco peregrinus* Tunstall), pigeon hawk (*Falco columbarius* Linnaeus), and the sparrow hawk (*Falco sparverius* Linnaeus).

GALLIFORMES (Fowl-like Birds)

The gallinaceous birds of the Rancho La Brea avifauna form a most interesting assemblage in which the lack of specific diversity is compensated by an extremely abundant representation of one member of this group. Only two types are known, of which the quail (*Lophortyx californica* (Shaw)) is similar to the species now inhabiting the region.

The extinct ground fowl (*Parapavo californicus* (Miller)) is unusually well represented, more than 700 individuals being recorded in the Los Angeles County Museum collection. In this assemblage are many young birds. In males the shank or tarsus of each leg has a strong spur, and the latter is slightly heavier than in the wild turkey. *Parapavo* approached the North and Central American wild turkey in size, and the skeleton was similarly proportioned. Nearest resemblance exists between this bird and the living ocellated turkey of Yucatan. The astonishing number of individuals found at Rancho La Brea clearly indicates that this form was the prevailing game bird of the region. Its value in furnishing a potential food supply for many kinds of carnivorous animals of the Pleistocene was probably very great. The ground habits of the extinct turkey may have made it particularly susceptible to entrapment in the tar pools. It is interesting to note that while *Parapavo* occurs abundantly in the Carpinteria Pleistocene, the species is not known at all from the McKittrick asphalt. Its absence at McKittrick may have been due to a lack of suitable ground cover.

GRUIFORMES (Crane-like Birds)

Representation of this group is restricted to the crane family for the most part. The types recorded are apparently identical with living species. The brown cranes (*Grus canadensis* (Linnaeus)) including probably the little brown and sandhill cranes occur more commonly than the whooping crane (*Grus americana* (Linnaeus)). A single bone of the American coot (*Fulica americana* Gmelin) also occurs in the collection.

CHARADRIIFORMES (Plover-like Birds)

These water-loving birds are not well represented individually, but several distinct types are included in the avifauna. Remains of the killdeer (*Oxyechus vociferus* (Lin-

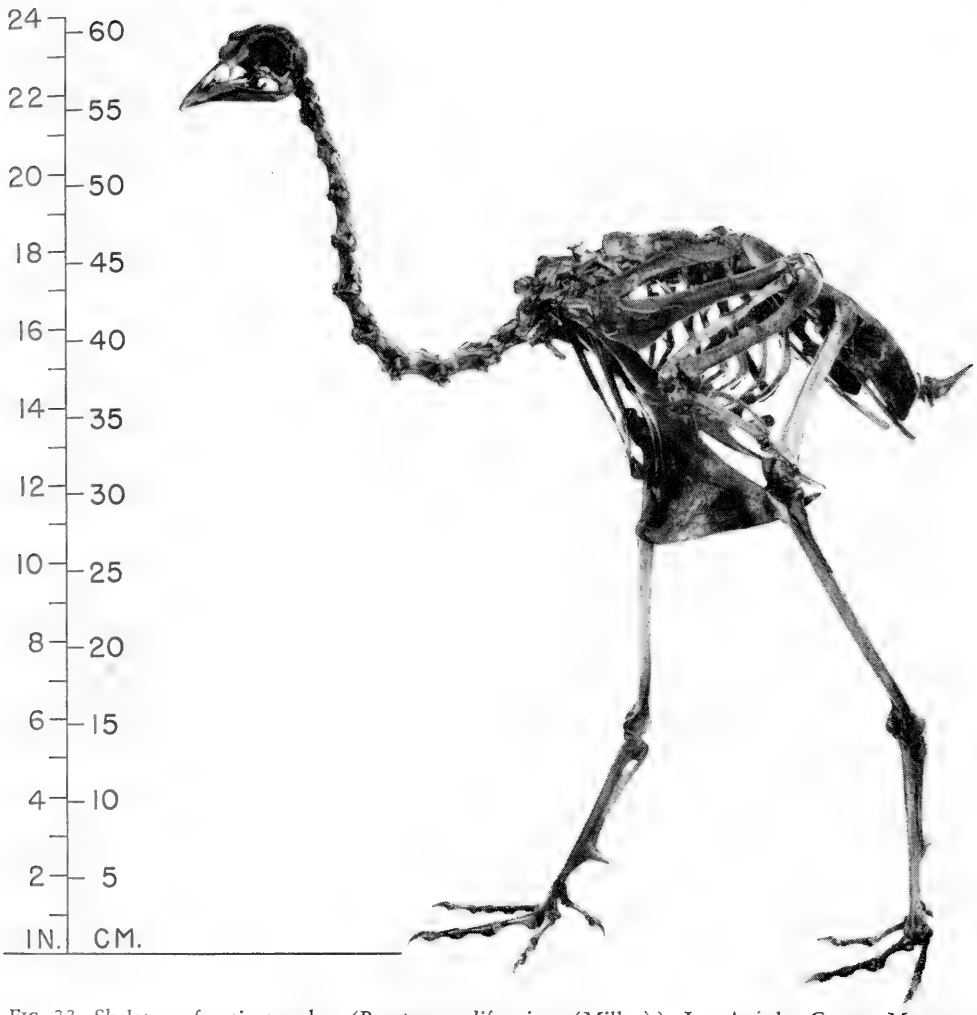

FIG. 33. Skeleton of extinct turkey *(Parapavo californicus* (Miller)). Los Angeles County Museum collection; Rancho La Brea Pleistocene.

naeus)), black-bellied plover *(Squatarola squatarola* (Linnaeus)), Wilson's snipe *(Capella delicata* (Ord)), greater yellow-legs *(Totanus melanoleucus* (Gmelin)), long-billed curlew *(Numenius americanus* Bechstein), hudsonian curlew *(Phaeopus hudsonicus* (Latham)), dowitcher *(Limnodromus griseus* (Gmelin)), marbled godwit *(Limosa fedoa* (Linnaeus)?), avocet *(Recurvirostra americana* Gmelin), and possibly the Pacific kittiwake *(Rissa tridactyla* (Linnaeus)?) and short-billed gull *(Larus brachyrhynchus* Richardson) have been found in the Rancho La Brea deposits. These and doubtless other members of the group were probably attracted to the region by temporary ponds or perhaps by films of water that occasionally covered the surface of the tar pools.

COLUMBIFORMES (Pigeons, Doves)

Both the band-tailed pigeon *(Columba fasciata* Say) and the mourning dove *(Zenaidura macroura* (Linnaeus)) occur in the Pleistocene asphalt. The fossil remains are re-

garded as not differing specifically from these living types. The pigeon presumably did not frequent the region of Rancho La Brea in great numbers, for only two specimens have been definitely determined as belonging to this form. The mourning dove is known by at least seventeen individuals, represented by twenty-nine specimens. This great number of doves in proportion to pigeons may express the predeliction of the mourning dove for an environment of open woods.

The passenger pigeon *(Ectopistes migratorius* (Linnaeus)) also occurs in the asphalt, represented by bones of three individuals. Once widely distributed over northern and eastern North America, this bird became extinct in 1914. Although now known to have lived in California during the Pleistocene, there is no definite record of its existence in this area during the Recent epoch.

CUCULIFORMES (Cuckoo-like Birds)

The sole representative of this group in the asphalt is the roadrunner *(Geococcyx californianus* (Lesson)), a species which still lives in California. Its presence in the fossil assemblage may be expected since the living bird is a ground-dweller. Moreover, a few remains of young birds have been found.

STRIGIFORMES (Owls)

All of the types of owls occurring at Rancho La Brea, with one exception, are apparently of species still existing. The fossil assemblage includes the barn owl *(Tyto alba* (Scopoli)), screech owl *(Otus asio* (Linnaeus)), great horned owl *(Bubo virginianus* (Gmelin)), pigmy owl *(Glaucidium gnoma* (Wagler)), burrowing owl *(Speotyto cunicularia* (Molina)), long-eared owl *(Asio wilsonianus* (Lesson)), short-eared owl *(Asio flammeus* (Pontoppidan)), and saw-whet owl *(Cryptoglaux acadica* (Gmelin)). The single extinct species is the brea owl *(Strix brea* Howard), related to but larger than the barred and spotted owls.

Miller (1925) has summarized the following salient facts regarding the occurrence of these nocturnal hunters in the Pleistocene avifauna of Rancho La Brea:

"1. As compared with diurnal raptors, owl remains are rare both in point of numbers and of species.

"2. This discrepancy is out of harmony with the balance of fauna as between nocturnal and diurnal raptors today.

"3. Owls were possibly less attracted to the asphalt trap than were hawks, although in Recent outpours owls are among the most commonly entrapped forms.

"4. More copious outpour during the Pleistocene may have resulted in rapid entombment of small forms, leaving only the larger victims exposed to view.

"5. Results of this more rapid entombment would be that the small hawks and the owls would find bait less constantly before them.

"6. Cooling of the Asphalt surface at night may have rendered the trap less dangerous to owls than to birds hunting by day."

Howard and A. H. Miller (1939) have found that the avifauna of pit 10, associated with the human remains and of later age than the typical Pleistocene deposits at Rancho La Brea, shows a marked increase in numbers of owls, small hawks, and falcons, and

concomitant decrease in numbers of the large condors and eagles, as compared with the Pleistocene assemblage. They believe that "This change in the raptors is significant particularly as it reflects the general change which has taken place in the entire fauna, that is, the disappearance of the larger Pleistocene mammals, the diminishing number of large non-raptorial birds, such as the stork and turkey, and the increasing numbers of the smaller mammals and birds." Similar changes are found in the McKittrick faunas, but differences between the older and younger assemblages are not so great as at Rancho La Brea. At Carpinteria the large raptors are less abundant than in the Pleistocene of Rancho La Brea, but in this case age does not appear to be the most important factor. It seems probable that the large raptors did not frequent this forested area, preferring more open country. The relatively great abundance of the extinct California turkey, which might be expected to favor brushy or wooded regions, seems to indicate that the Carpinteria asphalt fauna approximates in age the Pleistocene assemblage at Rancho La Brea (DeMay, 1941a, b).

PICIFORMES (Woodpeckers)

Of this group, only three species, the red-shafted flicker *(Colaptes cafer* (Gmelin)), pileated woodpecker *(Ceophloeus pileatur* (Linnaeus)), and Lewis woodpecker *(Asyndesmus lewisi* (Gray)), have been recorded from the Pleistocene of Rancho La Brea. Remains of flickers are not entirely unexpected in the asphalt in view of the ground feeding habits of the living birds. Since the Lewis woodpecker is associated today with the coast live oak, it is of interest to note that remains of this tree are relatively abundant in the Pleistocene deposits. The pileated woodpecker, however, seems quite out of place in the Rancho La Brea fauna. It usually inhabits extensive coniferous forests, and is found but rarely in areas as sparsely wooded as the Rancho La Brea region must have been in Pleistocene time.

PASSERIFORMES (Sparrow-like Birds)

No less than 36 different kinds of passerine birds have been recognized in the fossil assemblage chiefly as a result of studies by Alden H. Miller. Of this number twenty-seven, representing the horned lark *(Otocoris alpestris* (Linnaeus)), Steller jay *(Cyanocitta stelleri* (Gmelin)), California jay *(Aphelocoma californica* (Vigors)), yellow-billed magpie *(Pica nuttalli* (Audubon)), raven *(Corvus corax* Linnaeus), white-necked raven *(Corvus cryptoleucus* Couch), crow *(Corvus brachyrhynchos* Brehm), northwest crow *(Corvus caurinus* Baird), California thrasher *(Toxostoma redivivum* (Gambel)), sage thrasher *(Oreoscoptes montanus* (Townsend)), cedar waxwing *(Bombycilla cedrorum* Vieillot), loggerhead shrike *(Lanius ludovicianus* Linnaeus), western meadowlark *(Sturnella neglecta* Audubon), black-headed grosbeak *(Pheucticus melanocephalus* (Swainson)), evening grosbeak *(Hesperiphona vespertina* (Cooper)), pine siskin *(Spinus pinus* (Wilson)), goldfinch *(Spinus tristis* (Linnaeus)), brown towhee *(Pipilo fuscus* Swainson), spotted towhee *(Pipilo maculatus* (Swainson)), vesper sparrow *(Pooecetus gramineus* (Gmelin)), lark sparrow *(Chondestes grammacus* (Say)), black-throated sparrow *(Amphispiza bilineata* (Cassin)), sage sparrow *(Amphispiza belli* (Cassin)), chipping sparrow *(Spizella passerina* (Bechstein)), white-crown sparrow *(Zonotrichia leucophrys* (Forster)), fox sparrow *(Passerella iliaca* (Merrem)), and song sparrow *(Melospiza melodia* (Wilson)), are identical with living species. An extinct species of towhee *(Pipilo angelensis* Dawson), is also known. The type of food available during the active period

of the traps frequently attracted to this locality such omnivorous birds as the raven, the crow, and the magpie. The last is the commonest passerine recorded in the collections.

Additional forms which have been recognized include the kingbird *(Tyrannus,* sp.), chickadee *(Penthestes,* sp.), bluebird *(Sialia,* sp.), possibly the yellow-headed blackbird *(Xanthocephalus,* sp. ?), the redwinged blackbird *(Agelaius,* sp.), and the oriole *(Icterus,* sp.). Lastly, an extinct blackbird *(Euphagus magnirostris* A. H. Miller), and an extinct icterid *(Pandanaris convexa* A. H. Miller), believed to be related to living blackbirds and cowbirds, are described from this locality. Warblers are also present but their identity still remains obscure because of the close similarity of these small species, and the scarcity of distinctive skeletal elements in the Pleistocene collections.

In the light of the known habits and distribution of many of the living representatives of the passerines found fossil at Rancho La Brea it may be presumed that the opportunities for shelter and sustenance in the country about the tar pools were not unlike those indicated by the mammalian assemblage. One may reasonably infer from the variety and type of passerines in the fossil assemblage that the environment in the near vicinity of the tar pools included open meadows, ground with brush cover, as well as a terrain along small stream courses with characteristic plant and tree growth. Moreover, the passerine group suggests a region with climate probably less humid than that of the present, with temperatures similar or higher, and with annual rainfall only slightly greater.

REPTILES AND AMPHIBIANS

Remains of reptiles include scattered snake vertebrae and the fragments of carapace and plastron of turtles. The latter materials apparently belong to a type resembling the western pond or mud turtle *(Clemmys).* The record suggests the presence of occasional ponds or small water courses.

Skull and skeletal materials of toads also have been found in the asphalt. These represent a species *(Bufo boreas halophilus* Baird and Girard) still living, whose present distribution extends along the Pacific Coast from southeastern Alaska to southern California. An extinct species *(Bufo nestor* Camp), differing from the modern type in several structural characters of the skull is also recorded. Toads were apparently as abundant at Rancho La Brea during the Pleistocene as they are at that locality today. It is of interest to record in this connection that beetles similar to those now used as food by toads occur in numbers in the asphalt.

INVERTEBRATE FOSSILS

Invertebrate remains were incompletely known for many years, but the introduction of a new method of recovery of small specimens from the tar by Dr. W. Dwight Pierce of the Museum staff and his recent entomological studies of this material give promise of furnishing much new information. Until the studies are completed, only the facts already known are presented here. As indicated before (see page 18) several fresh water shells *(Lymnaea, Heliosoma)* were found in the subsurface deposits at Rancho La Brea. Ostracod shells are reported by Dr. Pierce, and these, as well as remains of water beetles (families: Hydrophilidae, Dystiscidae, Haliplidae) and water bugs (families: Notonectidae and Corixidae) indicate the presence of more or less permanent pools of water. A few fragments of marine mollusks have been encountered in the asphalt and these probably represent accidental occurrences or intrusions. Myriapods (Diplopoda) are represented by one

determined millipede *(Spirobolus australis* Grinnell), and multitudes of fragments of several species. The Arachnida are represented by a few spiders (Araneida and Phalangida).

The insects are by far the most abundant group, but their remains are usually fragmentary, consisting of stray head and body parts and chitinous wing covers. In addition to those mentioned above many kinds of fossil insects have been reported by Dr. Pierce, namely, Isoptera (termite droppings), Orthoptera (grasshoppers, crickets), Hemiptera (bugs), Homoptera (leaf hoppers), Coleoptera (beetles), Hymenoptera (wasps and ants), and Diptera (flies).

Fourteen families of beetles have been identified from the asphalt. On the basis of their ecological relationships they can be grouped as water beetles, carrion beetles, predaceous beetles, dung beetles, ground dwelling beetles, and plant feeding beetles including the weevils, thus giving some indication of the varying environmental conditions that prevailed. As yet little is known regarding the non-Coleopterous forms, but among the Orthoptera the Jerusalem crickets and the grasshoppers have been identified. The Diptera are known largely from puparia of blowflies and fleshflies. Among the Hymenoptera are the paper wasps and the ants. Among the Hemoptera are recognized the backswimmers and water boatmen. Many of the insects present are of types with heavy chitinous skeletons that have been assigned to genera and species now living in the region. There are, however, some exceptions, such as the dung beetles of two genera, which do not now exist west of the Rocky Mountains.

As stated in a previous section, some of the fossil insects at Rancho La Brea suggest that the disintegration of carcasses was a comparatively slow process. Several kinds of insects have been recognized that today are characteristic of particular stages in the cycle of disintegration of organisms which follows death. Thus, blowflies and fleshflies make their appearance soon after death and subsequent stages in the postmortem period are identified by the presence of dermestid beetles *(Dermestes),* of the silphid or burying and carrion beetles *(Nicrophorus* and *Silpha),* and of the histerid beetles *(Saprinus).* All of the insects mentioned have been recognized as fossils in the asphalt, and these are regarded by the entomologist as evidence indicating an exposure of decaying organic matter in and about the traps for a period of at least five months.

RECORD OF THE PLANTS

Because plants are as a rule excellent indicators of life zones and reflect in their present distribution the varying climatic conditions over geographic provinces, their presence at Rancho La Brea may be expected to yield interesting information regarding the climate during the period of accumulation of the Pleistocene asphalt. Many structural characters of plants are known to change but slowly in the course of geologic time, and it is therefore not surprising to find in so late a stage as that of Rancho La Brea species of plants identical with those living today in California. Interest largely centers in the association of plant types and in the comparison which can be made between their past and present distribution.

It is to be regretted that the Pleistocene plant life of this region is not more completely known. Relatively few types are recorded by the available fossil materials. Wood is the most common material and has been identified by a microscopic examination of its cellular structure. Occasional cones, seeds, and leaves assist also in making a determination of the various plants.

The pine family is represented in the asphalt by two cones possibly referable to the Bishop pine *(Pinus muricata* Don. ?). Regarding the distribution of this species today, Mason (1927) makes the following statement: "*Pinus muricata* is at present a relict with a scattered distribution. It ranges from Fort Bragg, Mendocino County, California, to north of San Quentin and on Cedrus Island, Lower California. It rarely reaches much more than a few miles inland from the sea – reaching to a distance of 10 miles inland on the summit of La Purissima Hills near Lompoc, Santa Barbara County, California."

Associated with the preceding species is a cypress, the specific identification of which is likewise in doubt. Evidently the Pleistocene counterparts of the several kinds of cypress known to grow today on the Pacific slope cannot be certainly identified in the region on the basis of fossil materials. Originally determined as Monterey cypress *(Cupressus macrocarpa* Hartweg), the species found at Rancho La Brea is now thought to be some other cypress (see below, statement quoted from Mason). The juniper *(Juniperus californica* Carr) is abundantly represented in the Museum collection by sections of trunks and branches, fragmentary leaf parts and seeds. Although identified as the California Coast Range juniper, the tree may be more closely related to the juniper now growing in the desert mountains of the southwest, and called *J. californica* var. *utahensis.* The latter is sometimes regarded as a distinct species. Although remains of the juniper are very abundant at Rancho La Brea, they are relatively quite scarce in the Carpinteria asphalt. Chaney and Mason (1933) state that "It seems possible to conclude that the habitat at Rancho La Brea was such that the junipers were commonly distributed adjacent to the sites of deposition, while at Carpinteria they were so remote that only rarely did they enter the fossil record."

The coast live oak *(Quercus agrifolia* Nee) has been recognized by the remains of its wood, leaves, and seeds. Manzanita *(Arctostaphylos)* fruits are also present. In addition to these forms the cockle burr *(Xanthium calvum* M & S.), the blue elderberry *(Sambucus glauca* Nutt.), and the western hackberry *(Celtis mississippiensis* Bosc. var. *reticulata* Sarg.) have been identified in the collections.

With regard to the climate of the Los Angeles area in Pleistocene time, Compton (1937) quotes Dr. Herbert L. Mason as follows: "The flora of Rancho La Brea suggests interior arid conditions such as are today found well up on the south slopes of the Tehachapi mountains. All of the species thus far reported from the flora except the pine and cypress can be found there. The taxonomic aspect of the pine is in doubt. The cypress could as well be similar to *Cupressus nevadensis* as to *C. goveniana* or to *C. macrocarpa.* As I have pointed out in print (1927, p. 156) one cannot determine positively the species of cypress on such fragmentary material as is represented in the La Brea Flora. The preponderance of *Juniperus* of a type now living in the Tehachapi and not to be found at all on the coast should be conclusive."

As Chaney (1938) has drawn the botanical picture, the cool humid flora known to have extended southward along the California coast during the late Pleistocene, and so well exemplified in the brea beds of Carpinteria, included at Rancho La Brea a definitely interior element.

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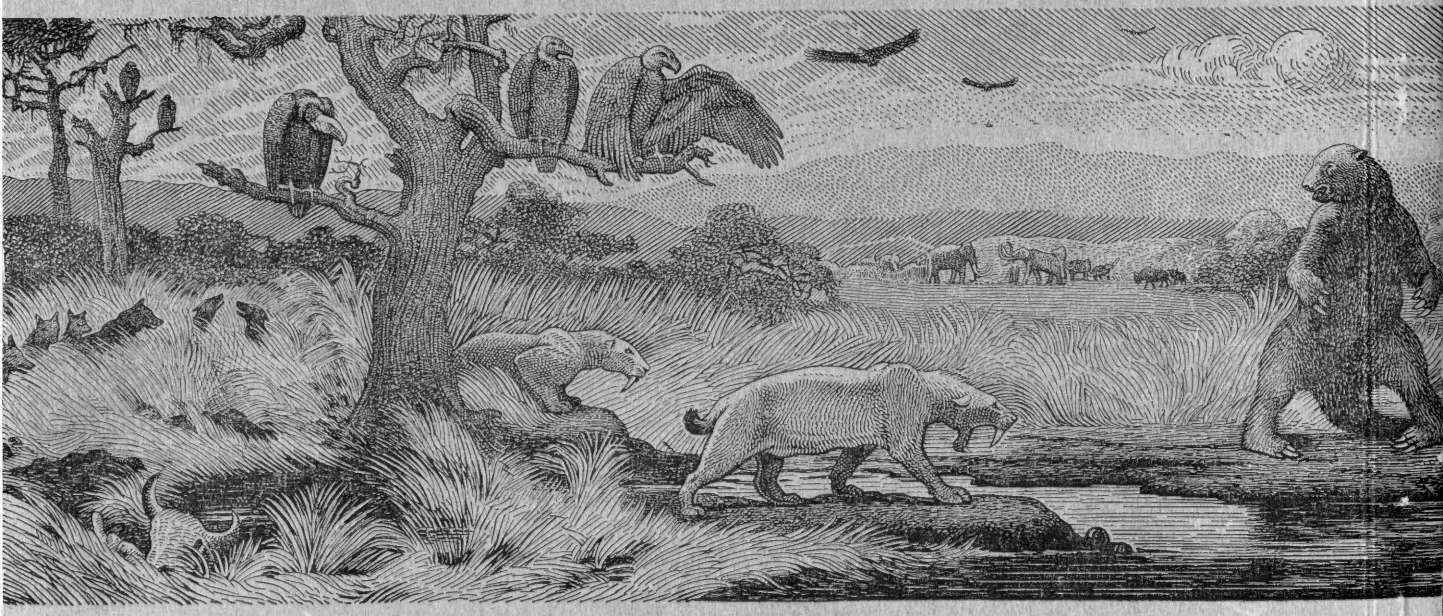

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